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Compressed Air Magazine

JAN 14 1921

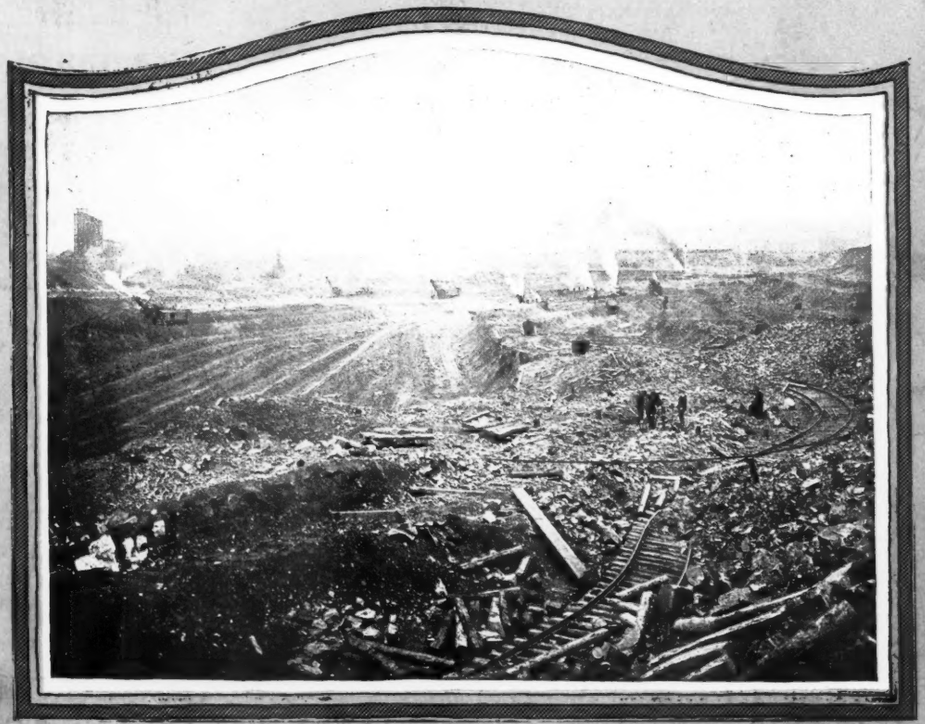
Vol. XXVI, No. 1 London New York Paris $3 a Year

JAN 14 1921

JANUARY, 1921

25th ANNIVERSARY NUMBER

(See Page 9950)



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Smashing Angry Seas With Bubbles of Compressed Air
Robert G. Skerrett

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Bessemer Beginnings
Frank Richards

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BAKER COOLER

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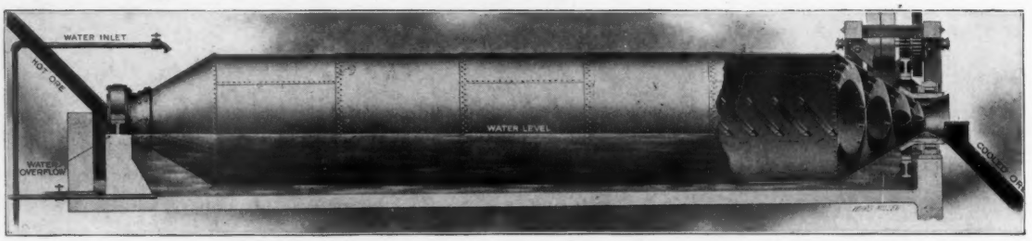

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VOL. XXVI, NO. I

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JANUARY, 1921

Smashing Angry Seas with Bubbles of Compressed Air

Pneumatic Breakwater Proves Effective in Protecting Coast Lines and Structures along Water Front Exposed to Storms—Successful Installations Warrant Further Adoption of this Method

By ROBERT G. SKERRETT

THE WORLD over incalculable damage is done every year by the relentless battering of storm-driven billows. Great masses of the angry sea heave their bulks against interposed shorelines and hammer away with angry violence, tearing, breaking, and eroding any resisting body standing athwart their thundering paths.

Carefully conducted dynamometer tests have revealed storm waves to have an impacting force of quite three to four tons to the square foot. Conceive, then, what must be the power to wreck and to wrack of mountainous rollers built up of the onward surge of hundreds of tons of water! From season to season, as long as man has recorded the fact, the recurrent tempest has thus attacked rocky headlands, sandy beaches, and other coastal formations; gradually and for the most part irresistibly modifying the contours.

It is said that England, since the days of Ceasar, has been robbed of a belt of terra firma three miles deep throughout the entire reach of her eastern coast. Village after village has slipped into the sea as the waves undercut the shore; and we are told that anywhere from 30 to 40 feet of water now overlies the former sites of thriving towns. We all know what Holland has had to do at various points to barricade herself against the gnawing, greedy North Sea; and the Zuyder Zee, in the very heart of that little nation, is an ever-present reminder of the hamlets and cities that were either submerged or otherwise affected to their detriment when that body of water was born—the consequence of an especially violent series of winter gales.

Over here on our own side of the Atlantic, our coast line is changing ceaselessly from Cape Cod south to Florida; and this restlessness is likewise manifest throughout the littoral of our Gulf States. Within the course of a little more than two centuries, the coastal formations contiguous to the port of New York have altered profoundly; these changes bearing evidence to the effects of erosive breakers and the insidious sweep of ocean currents. Along the shore of near-by New Jersey, just where there is a popular resort section, solid land has gradually given way to the sea until high water extends a hundred feet further inland than it did a generation ago. Speaking of the agencies that have brought this about, an eminent local authority on coastal protection has said:

"Our physical situation here is a peculiar one, and the forces that built this peninsula might, in time, sweep it away. In the past the north and the south branches of the Shrewsbury River were independent water courses and flowed directly to the sea instead of uniting and traveling northward to join the Navesink River and then onward and outward inside of Sandy Hook. That meant that the channel now back of Seabright was probably part of the mainland, and that this whole peninsula slid seaward because of the undermining action of the north-bound current, which survives to-day. Indeed, a little to the south of us, I have uncovered, in boring, pine forests with the tops of the trees now fourteen feet below the level of low tide, and the timber was as sound as wood cut to-day. On top of this has been laid the sand which we now know."

Assateague Anchorage, midway between the Delaware River and Chesapeake Bay, which is a frequent place of shelter for coastwise shipping, did not exist 60 years ago. But in 1849, owing to the drive of winter storms, a sand spit was heaped up which started to build southward from the lower point of Assateague Island—gathering bulk and added length with each succeeding year. From 1908 to 1911 the rate of development was something like 200 yards annually, and from that time on the accumulating sand has added each year about 100 yards to the sheltering barrier. Thus, the material stripped from one stretch of the coast has been transplanted to increase the visible area of another section.

While these processes may go on in some regions without occasioning monetary sacrifices to any one, there are places where the scouring action of either the surf or the tidal sweep is bound sooner or later to entail property losses of magnitude. Therefore, in order to protect their seaside holdings, the people concerned have found it necessary to resort to two expedients: jetties projecting seaward at right angles to the prevailing erosive currents, and sturdy bulkheads designed to withstand the direct battering of storm-tossed breakers. The story of these efforts, involving expenditures of vast sums in the aggregate, is not a heartening one.

Occasionally, these defenses against the sea have stood up to their tasks for a while, only to be smashed into splinters or hopelessly wrecked by a single storm of outstanding severity. Bulwarks of heavy pine planking, supported by deeply-sunken piles and reinforced by tie rods, etc., have been crushed and obliterated as if they had been fashioned of nothing stronger than matches. With these barriers swept aside, the racing billows have cut into the land ruthlessly—either washing habitations away bodily or destroying their foundations so that collapse was inevitable.

A little knowledge of the energy stored up in tempest-bred rollers should make it plain how futile, in the long run, are these wooden barricades, which are so constructed and placed that they are expected to withstand the frontal blows of the tumbling waters.

At Bilboa, on the Bay of Biscay, years ago, Spain built a very costly breakwater to guard shipping during the prevalence of stormy winds. The structure stood up very well until subjected to the seas created by a tempestuous blow in 1894. Then, the waters of the Bay of Biscay breached that buttress, and the

Illustrating the way in which a temporary air breakwater would be used to protect a stranded ship from the surf.

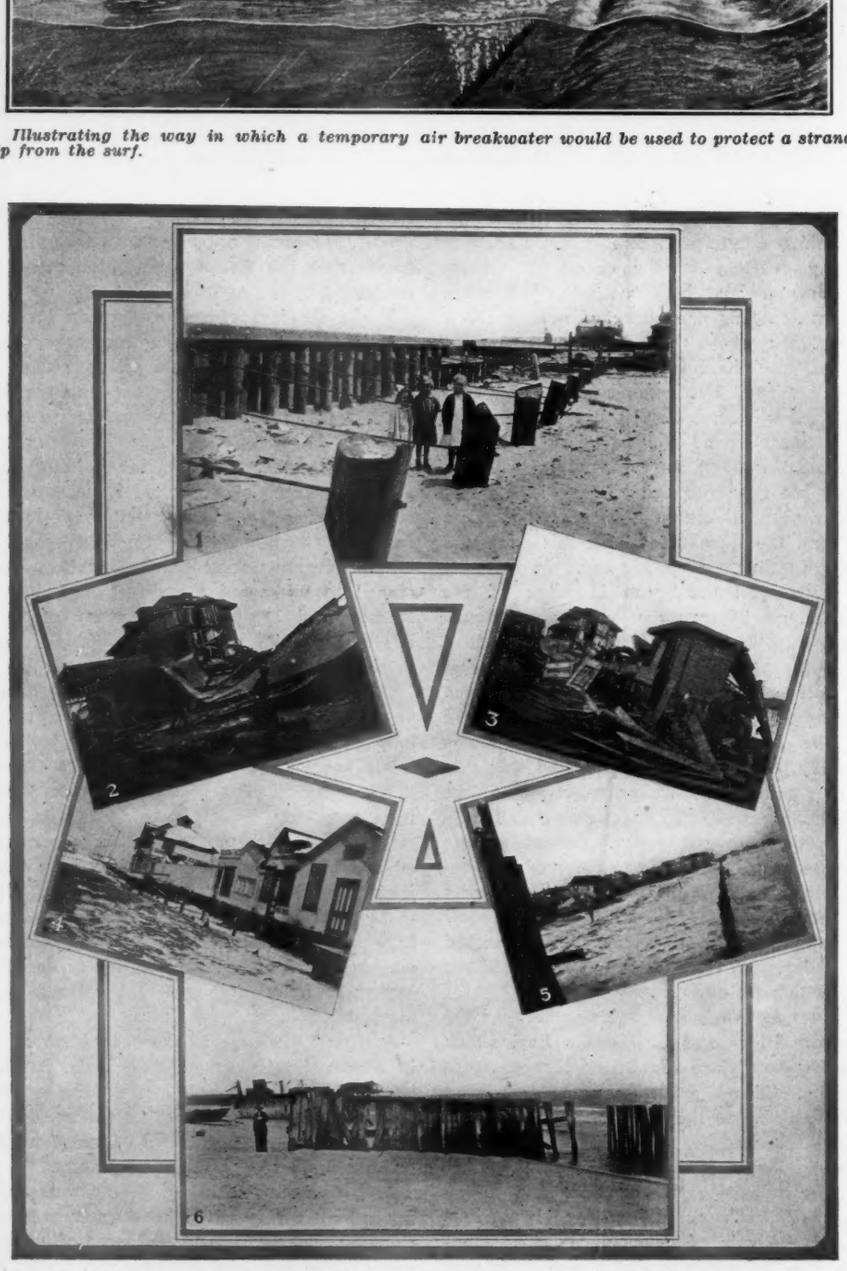


Fig. 1—A section of Brighton Beach houses after a winter storm. Fig. 2—A victim of the undermining sea. Fig. 3—What was left of a large hotel after the storm waves reached it. Fig. 4—The stripped pilings of a bulkhead at Seabright, N. J., immediately after an easterly gale had broken through the houses just in shore. Fig. 5—The rear view of a bulkhead at Seabright, N. J., reared after the disastrous storm of a few years ago. Note the getup of the structure. Fig.6—Wrecked jetties on the New Jersey coast. What the surf does to the barriers interposed by man.

force of the assaulting surge was sufficient to dislodge one great monolithic mass, weighing about 1700 tons, and to impel it shoreward a distance of 105 feet. Most of us can recall how the sea wall at Galveston was shattered a few years back when a hurricane in the Gulf of Mexico hurled a piled up and angry flood against that barricade reared by the Federal Government.

The story is much the same wherever the protection of property and the safeguarding of loading and discharging shipping has called into being unyielding artificial shields intended to withstand the irresistible impact of the battering billow. And yet the all-too frequent futility of these fending arms is not appreciated, for port after port and government after government places reliance in them —spending the while vast sums of money.

Bitter experience is responsible for much that we learn that is worth while; and Philip Brasher, a civil engineer, is indebted to hard luck for the lesson that led him to devise his so-called compressed-air breakwater. To protect a business venture in which he and others were interested at Brighton Beach, New York, nineteen years ago, there was built a bulkhead to halt the threatening surf beating against the south shore of Long Island. One night, not long after the defense was finished, a storm smashed the structure, and in a few minutes ruined a work that represented an expenditure of $40,000. It was plain to Mr. Brasher that it would be a waste of money to again rely upon a rigid bulwark to stop great mobile masses of wind-impelled water. He felt that something radically different was needful.

Having done his bit as a cow puncher and an expert football coach, he knew that a runaway steer or a racing player could be best brought to earth by pulling his legs from under him.

Somewhat in the manner of an inspiration the thought came to him suddenly, after he had pondered the subject for a while, that compressed air injected into the body of a billow would serve this end. But before explaining the method finally adopted by this ingenious engineer let us consider the nature of a deep-water wave.

Wave motion, broadly speaking, is a transference of energy by vibration, and may or may not, according to the nature of the wave. induce an actual advance of the wave-mass. Therefore, we have waves of two sorts, those that merely rise and fall by reason of the oscillations of their constituent particles and those that tumble onward pounding violently with the force of their falling waters. The oscillatory wave is well exemplified in the case of a vigorously shaken blanket. The fabric ripples from the hands outward to the farther edge, deceiving the eye by the apparent translation of the material, but even so the blanket as a whole does not move on. In a kindred manner the surface of the sea is agitated in deep water without the substance of the ocean shifting its position.

It is only when the oscillatory wave reaches shallow depths, where there is not vertical

space sufficient for it to gyrate freely agreeable to its acquired vibratory impulse—in other words there is not beneath it an ample bed of supporting water, that the wave loses its balance, begins to tumble, and its whole mass is urged forward. At this stage, the oscillatory wave is changed into a wave of translation, popularly termed a breaker, and its descending body becomes a battering ram capable of hammering more or less violently any rigid obstacle standing in its path. The higher the upset wave, and the greater its speed and weight, the more its momentum and power to damage.

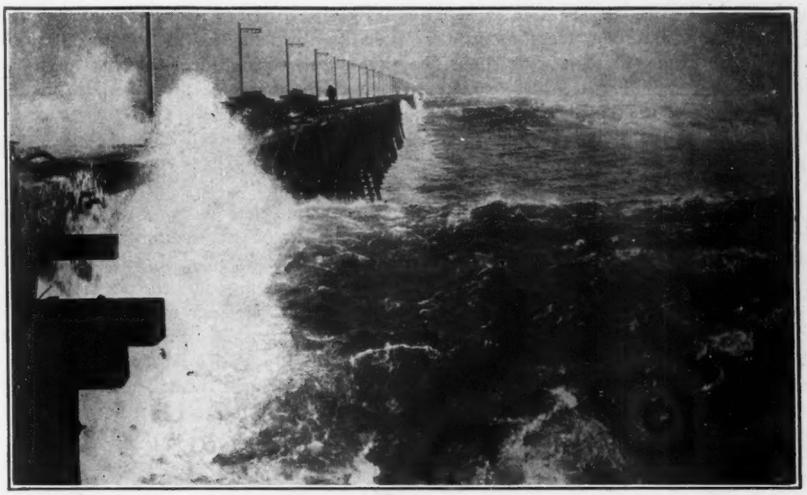
From the very start, Mr. Brasher sought to attack storm waves at a point well off shore, while they were rolling smoothly onward and still the offsprings of vibratory impulse only. He knew that he could not deal with the tremendous rush of big breakers. And now for the method by which he dissipates the menacing wave by compressed air. Just as in the case of the steer and the football runner, his line of attack is from below; and his tripping agency is a wall of rising air bubbles driven upward through the water along the line of least resistance.

As he explains: "When two forces moving at right angles meet, the resultant force acts at an angle to the initial forces. Therefore, when this rising air meets the water in motion due to wave action, the direction of the motion of the water is changed to such an extent that the continuity of the wave is broken and it collapses. That is to say, every particle of water going to make up a wave is acted upon by a body of air capable of lifting it and retarding its forward motion. It follows, then, that the water which should flow back to form a base or a foundation for the next oncoming wave is so delayed that the succeeding wave, finding no support, curls over and breaks."

For the subaqueous distribution of his air Mr. Brasher employs a perforated pipe laid athwart the line of advance of the seas to be dealt with. The size of the pipe, the spacing of the outlets, and the volume of the air are dependent upon the operative depth and the nature of the problem imposed by local physical conditions.

A basic patent was granted him in 1907, after six years of experimental research and progressive demonstrations. Satisfied in this way that he was right, he subjected his system to practical application under varying circumstances, such as changing depths of water and different characters of bottoms, i. e., mud, sand, and rock. In the course of that work he established the fact that waves of great height could be broken up so that the remaining surge was incapable of doing injury. His third installation was particularly encouraging in its performance.

In the summer of 1908, a fairly large plant was assembled at Crotch Island, Maine, where the wharf of a quarry was so exposed that boats could not be loaded when the wind was blowing in a blustering fashion from the east. The object of the air breakwater was to afford protection to the vessels at all times. When put to a crucial test, the waves were



The great pier at El Segundo looking shoreward from its outer end. The air breakwater robbed these billows of their damaging might.

Men at work placing the Brasher air breakwater off the great pier at El Segundo, Calif.

Another view of the work while placing air breakwater off the pier at El Segundo, Calif.

rolling in so high that they sent their spray flying over the tops of the trees along the shore. Within fifteen minutes after compressed air was sent bubbling surfaceward, the water lying inside of the breakwater was smooth enough for the superintendent of the quarry to paddle about in a canoe!

The fourth application of the system was for a very different service. It was employed to shield the *U. S. S. Yankee* from the open sea while being salvaged. The *Yankee* had been run upon the rocks of Hen and Chickens Reef, near Cuttyhunk, Massachusetts, in 1908, during a thick fog, and her exposed position had at first hampered the wreckers. To neutralize this menace in windy weather, Mr. Brasher proposed his air breakwater, which was adopted. The air supply for the outlying, submerged, perforated piping being furnished by the ship's compressors. The performance of the apparatus in that case is said to have been exceedingly helpful and, withal, quite remarkable.

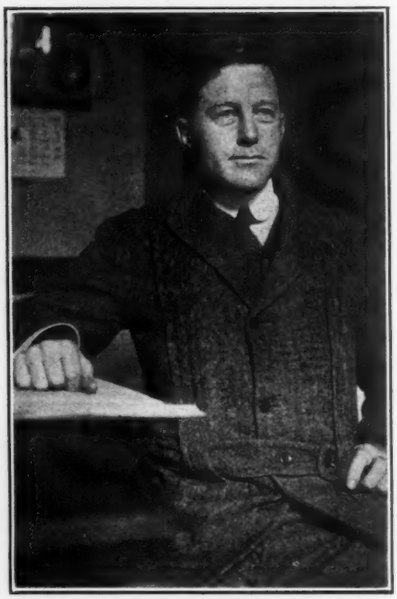
In one instance, when heavy seas were boarding the *Yankee* fore and aft, and causing her to grind upon the rocks upon which she rested, their power to do harm and to interfere with the salvors was checked immediately after air was discharged from the equipment. The air breakwater created to leeward of it a lagoon of comparatively quiet water—the seas breaking harmlessly at the line of up-shooting air bubbles.

With the salvage of ships more than ever a very live question for the engineering fraternity, the Brasher air breakwater promises to be of notable value in the successful prosecution of this department of marine undertaking. As is fairly well known, one of the greatest and one of the most uncertain factors in refloating a wrecked vessel is the state of the sea. Neither the wrecking craft nor divers can do their work effectively or safely when even a moderate sea is running, and this restricts the period of operations and also determines to a considerable extent the season of the year in which the salvage efforts can be pushed.

Therefore, without further explanation, it should be self-evident that an air breakwater, such as Mr. Brasher is able to create promptly, should prove a veritable boon; for the sooner an imperilled ship is taken in hand and raised or released the less she is likely to be hurt and the greater the quantity of her cargo which may be recovered undamaged. Well-nigh every up-to-date salvage steamer carries compressors of generous capacity.

For a time during 1911 and 1912, a Brasher air breakwater was in use in the neighborhood of Gloucester, Massachusetts, where it was placed to insure shelter to shipping lying at a quarry wharf. Up till then, the stone company's boats could not load at the dock except when the sea was virtually calm; and the region of Cape Ann is not a section of the American coast where tranquillity prevails. The photographs accompanying this article show clearly the exposed position of the dock and likewise illustrate how effectually the breakwater provided an area of relatively smooth sea even when a stiff wind was blowing.

The depth of the water was 40 feet at high tide, and the bottom was rocky. The installation consisted of four-inch iron pipe which entered the water at the dock head and then ran out along the bottom for a distance of 100 feet. At the seaward end of this section a connection was made with 300 feet of the same size conduit, laid upon the waterbed at right angles—thus forming a great T. Perforations one-quarter of an inch in diameter were spaced six inches apart throughout the reach of the latter piping; and the air feed amounted to three cubic feet per minute for each linear foot of this conduit. The pressure of the air was just sufficient to overcome the hydrostatic head. The circumstances under which this plant worked were somewhat more severe than



Philip Brasher, the inventor of the compressed air breakwater.

those that prevailed at Crotch Island, Maine. And now for the most spectacular application of this type of sheltering barrier.

Some years ago, one of America's biggest oil companies built a pier seaward for a distance of 4100 feet at El Segundo, California—a point on Santa Monica Bay just north of San Pedro. It was the third attempt by the concern to provide an ocean shipping station for oil derived from the southern fields of that State. February, five years back, a storm swept in from the broad Pacific and demolished 2,000 feet of the outer section of the wharf, and only the subsidence of the gale saved the rest of the structure. Even so, there was the best of reasons for believing that the next heavy blow would sound the doom of the remaining 2100 feet of that very necessary and extremely costly dock.

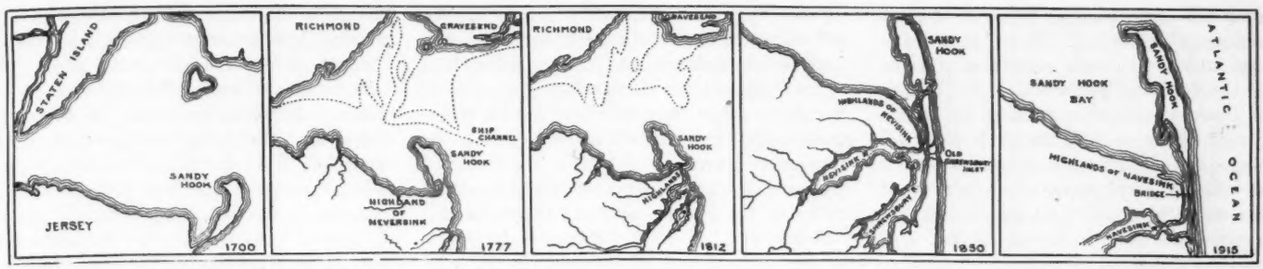
In the typical spirit of the Westerner, the engineer in charge was not averse to something new, if it promised well, and he readily agreed to give the Brasher air breakwater a trial. He was fully alive to the commercial importance of maintaining berthing accommodations for loading sea-going tankers. Mr. Brasher proposed a triple defense against storm waves for that very exposed pier which, up to that time, had been damaged to the extent of quite half a million dollars. But his plan was adopted only in part. As installed, the pneumatic breakwater was composed of an arc-like arrangement of four-inch piping, having a length of 170 feet, resting on the seabed 145 feet out from the pier head and, generally speaking, parallel with the front of the wharf. The pipe was supported by stakes five feet long, driven into the sandy bottom, and the depth of water was 30 feet.

The three pipe sections of this sector were assembled and then floated into position by casks. The air was furnished by a three-inch conduit connected to each end of the breakwater; and to make the planting of the latter easier, each supply line was formed of three-inch hose for a distance of 50 feet from its union with the breakwater. These, for the nonce, reached to the surface until the breakwater pipe was lowered in place and secured, and then the flexible links were coupled to three-inch iron-pipe sections which, in their turn, were laid on the ocean floor and carried back to the pierhead, where they tapped the already existing compressed-air line. The latter extended inshore for two miles to a station equipped with twin compressors, each capable of furnishing 1,000 cubic feet of air per minute.

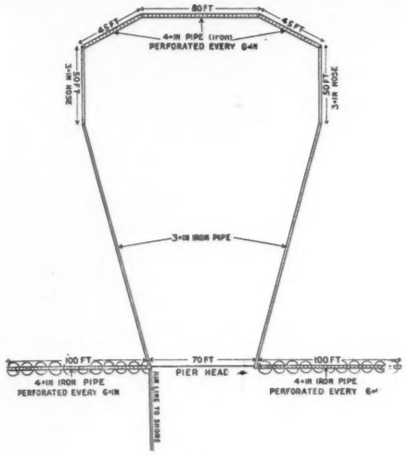
To supplement the action of the outlying breakwater, two wing breakwaters, also composed of four-inch iron pipe, were run on the seabed for 100 feet in line with the face of the pierhead, and projecting therefrom. Their function was to make a second attack upon any waves not effectually dealt with by the advance wall of air bubbles, and also to insure better protection to the 2100 feet of the wharf lying rearward. The whole equipment had not been in place long before it was subjected to a crucial test. In January of 1916, a violent gale struck the Pacific coast, doing an immense amount of damage to property. The waves ranged in height from twelve to fifteen feet, and raced shoreward with menacing frequency. It was a kindred blow that had previously carried away 2,000 feet of the pier.

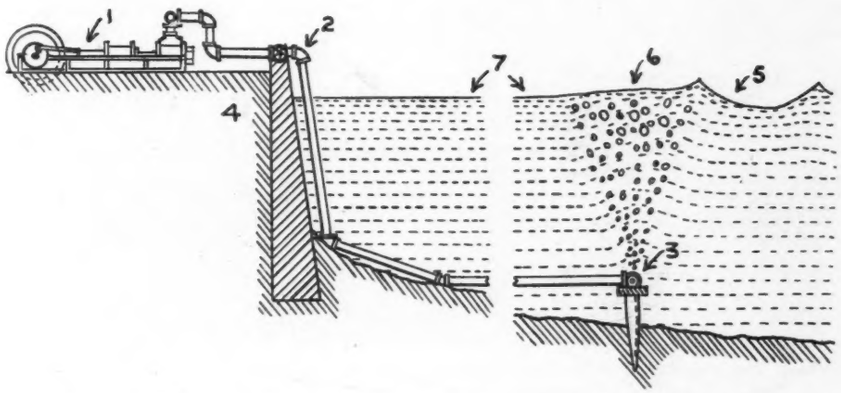
For 23 hours the wind raged and the billows rolled onward as if they would shatter any and everything standing athwart their paths; and for the same period compressed air was fed continually into the perforated conduits of the pneumatic breakwater. The disruptive action of the relatively puny ascending bubbles sufficed to sap the seas of their harmful urge, and from there on the waves traveled alongside and through the pilings without force enough to wrack those supports! The running of the compressors for the entire interval did not involve an expense of more than $60.00; and the dock came through the tempest unscathed.

It has been said by the skeptics that a breakwater of this description, especially when laid upon a sandy or muddy bottom, would soon fill up with silt or be buried too deeply to function when air was turned on. In a measure that did happen at El Segundo: the sand gathered over the four-inch perforated mains.

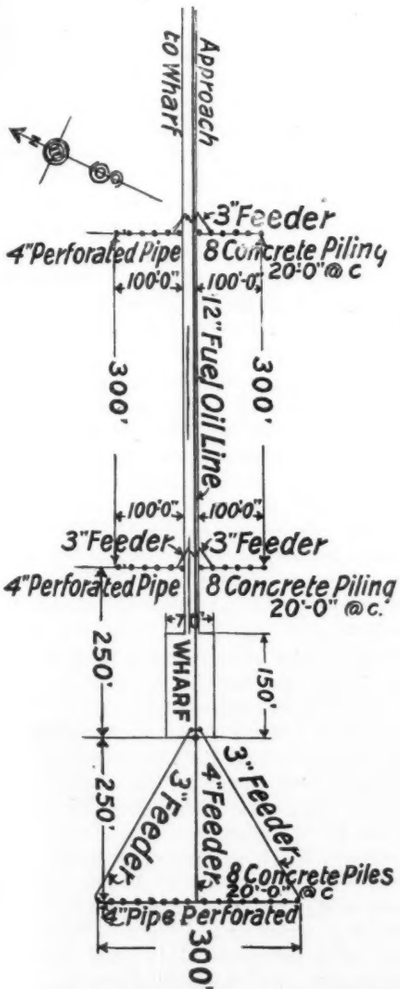


A section of the Atlantic seaboard that has undergone radical transformation in the course of 220 years. Bulkheads and jetties have been employed to arrest this action with only temporary and trifling benefits.

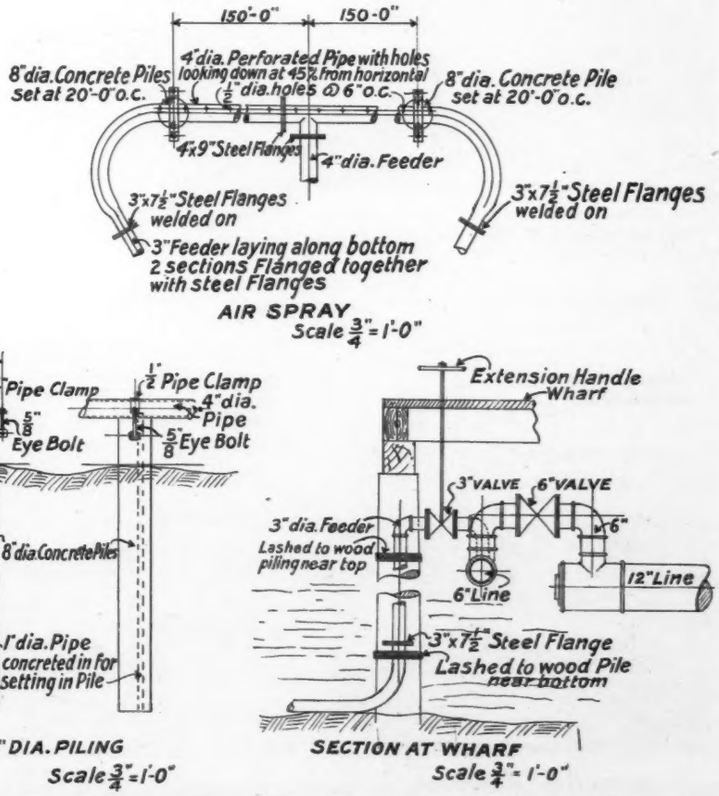




A schematic sketch of the operative features of a Brasher compressed air breakwater. 1—Air compressor; 2—Air supply line to breakwater; 3—Perforated pipe of breakwater; 4—Pier to be protected; 5—Area of rough water; 6—Ascending and expanding air bubbles. 7—Area of calmed water.



Upper, 1st installation; lower, 2d installation at El Segundo.

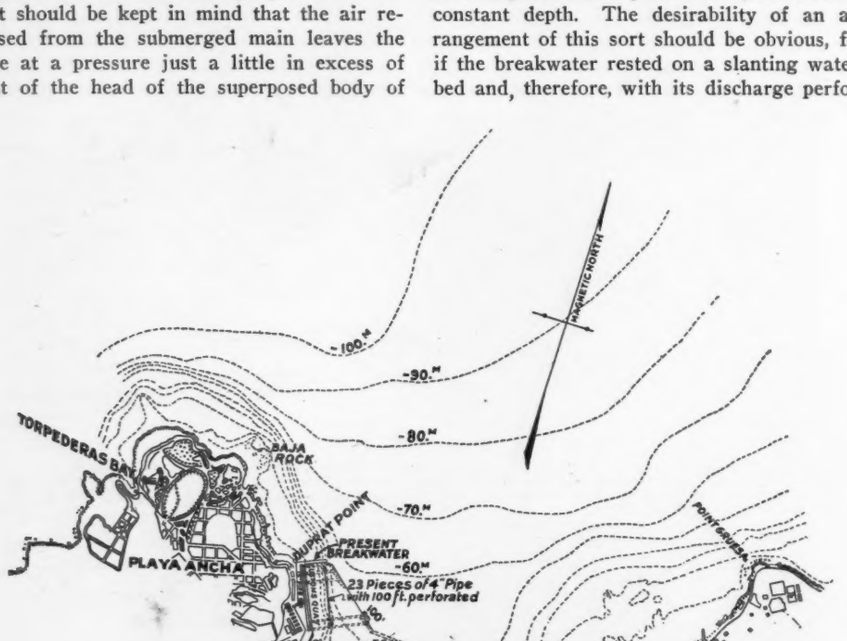

150'-0"
150'-0"
8" dia. Concrete Piles Set at 20'-0" o.c.
4" dia. Perforated Pipe with holes looking down at 45% from horizontal
1/2" dia. holes @ 6" o.c.
8" dia. Concrete Pile set at 20'-0" o.c.
4"x9" Steel Flanges
4" dia. Feeder
3"x7 1/2" Steel Flanges welded on
3"x7 1/2" Steel Flanges welded on
3" Feeder laying along bottom 2 sections Flanged together with steel Flanges
AIR SPRAY
Scale 3/4" = 1'-0"
11"
4" dia. Pipe
1" Pipe Clamp
1 1/2 Pipe Clamp
4" dia. Pipe
5/8" Eye Bolt
5/8" Eye Bolt
8" dia. Concrete Piles
1" dia. Pipe concreted in for setting in Pile
8" DIA. PILING
Scale 3/4" = 1'-0"
Extension Handle
Wharf
3" VALVE
6" VALVE
3" dia. Feeder
Lashed to wood piling near top
6"
12" Line
6" Line
3"x7 1/2" Steel Flange
Lashed to wood Pile near bottom
SECTION AT WHARF
Scale 3/4" = 1'-0"

Details of compressed air breakwater protecting El Segundo wharf.

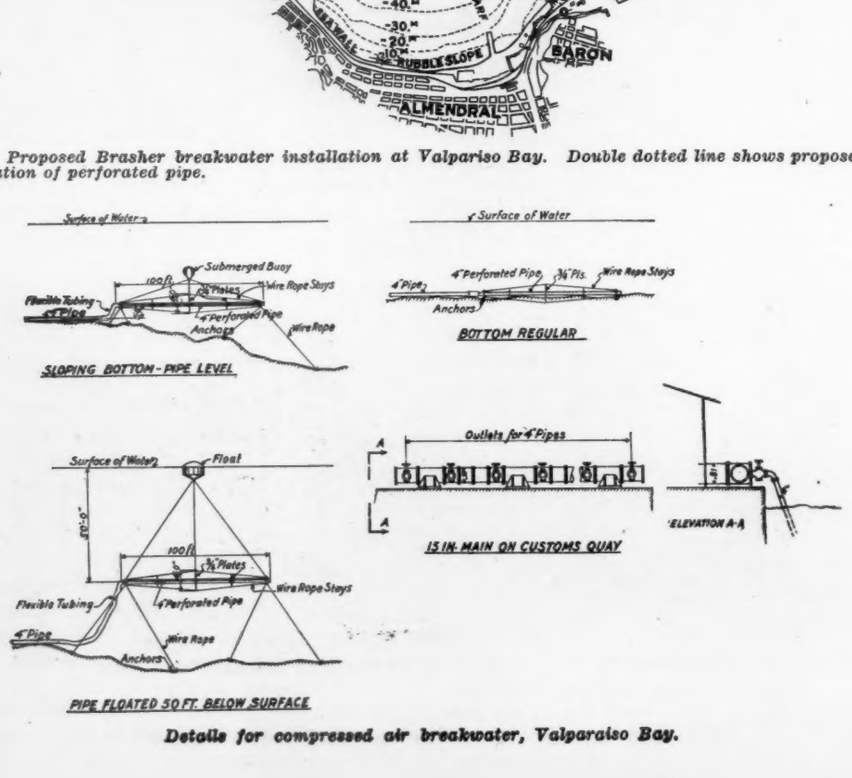
However, the compressed air made short work of that overlying blanket. In order to minimize the intrusion of solid matter, entering by way of the discharge perforations, Mr. Brasher has found it desirable at times to set his breakwater piping so that the air outlets will be underneath. Thus, when the air charge is turned into the breakwater, any silt or sand that has managed to work its way in is easily blown down and out. Jockeying the air, i. e., sending the compressed air into the breakwater in successive impulses, tends to break rapidly any obstructions and to blow their shattered particles out into the enveloping water.

It should be kept in mind that the air released from the submerged main leaves the pipe at a pressure just a little in excess of that of the head of the superposed body of water. The air immediately forms bubbles, and these expand as the hydrostatic pressure diminishes surfaceward. Thus, there is a continuing and an increasing explosive or disruptive effect, and it is this which disorganizes the internal vibratory cycle of the deep-water wave.

Of course, great depth of water and the nature of the seabed combined therewith may prohibit the placing of the breakwater mains on the bottom, and where such is the case, Mr. Brasher has provided an alternative scheme wherein the discharging conduits are held suspended at a predetermined and fairly constant depth. The desirability of an arrangement of this sort should be obvious, for if the breakwater rested on a slanting waterbed and, therefore, with its discharge perforations at varying depths, it would be next to impossible to insure a uniform emission of air throughout the length of the pipe. Therefore, while the wall of bubbles would be capable of breaking up waves at one point it might not be vigorous enough to do so when ascending from the deeper sections. That is, the air under a constant pressure from the compressor would naturally escape faster and in greater quantity through the outlets offering the least resistance.



Proposed Brasher breakwater installation at Valparaiso Bay. Double dotted line shows proposed location of perforated pipe.



Details for compressed air breakwater, Valparaiso Bay.

There are ports in some parts of the world where the water is very deep a short distance from the shore and these would seem to call for floating breakwaters suspended beneath the surface, possibly at a depth of 50 feet and, therefore, well above the seabed. A typical case is that of the harbor of Valparaiso. The Chilean Government has already spent a large sum of money in an effort to afford protection there to shipping during the prevalence of the dreaded "northers," which are free to drive the storm seas directly into the open bay upon which the city lies. Within a span of a few hundred yards, in the vicinity of the Customs Quay, soundings drop rapidly from 33 feet to 197 feet.

In July of 1919, on a fateful Friday night, a storm of terrific violence—the worst since the one made memorable in 1876, struck Valparaiso, and before it had spent itself a hundred lives were snuffed out and nearly $50,000,000 worth of damage was done to shipping, harbor structures, and adjacent property. The existing breakwater was breached and otherwise injured in various places, and it was established conclusively that such a defense was of little avail when the Pacific was in a really turbulent mood. The Chileans have proposed the building of a breakwater to shield only a very restricted section of the harbor and to expend thereon the very tidy sum of $9,000,000. To so barricade the whole throat of the port would call for an outlay of $27,000,000.

Mr. Brasher is satisfied, from his experience and his survey of the port, that it would be practicable to furnish an efficient pneumatic breakwater across the entire harbor entrance for $1,000,000. This, of course, would include the necessary compressors or possibly a battery of turbo blowers, which would be able to provide a plenty of air at the necessary maximum pressure of 25 pounds—the breakwater mains to be held at a depth not in excess of 50 feet.

Two of the photographs reproduced with this article illustrate the condition prevailing on our northwest coast where a large lumber company has one of its plants. Not only is the rise and the fall of the tide considerable but the precipitous nature of the shore and its exposure to certain winds have made it impracticable to construct a wharf there. Accordingly, vessels are loaded by means of an aerial conveyor—the terminal cable being secured to the craft well out and at anchor.

During something like eight months of the year, when northwest winds blow, loading in this fashion offers no great difficulties, but in the wintertime the southerly storms interfere

with shipping and not infrequently oblige the freighters to lie idle outside the cove anywhere from a week to ten days. The waves at that time are known to break in eleven fathoms of water. It would seem that the Brasher system would be admirably fitted to afford the protection needed there. This point is not unlike many others along the Pacific coast of America.

In the Hawaiian Islands there are numerous harbors and landings where sugar from most of the plantations is collected by small steamers which transfer their cargoes to ocean-going craft at the few large ports. Well-nigh all of these landings are said to be exposed more or less to the sweep of the open sea, and at some places the steamers cannot tie up to a dock but are anchored a distance from the shore and loaded by means of wire-rope cables. A pneumatic breakwater would therefore serve in our Island possessions to safeguard not only existing wharfs but to facilitate the handling of commodities which is now subject to interruption at certain seasons of the year.

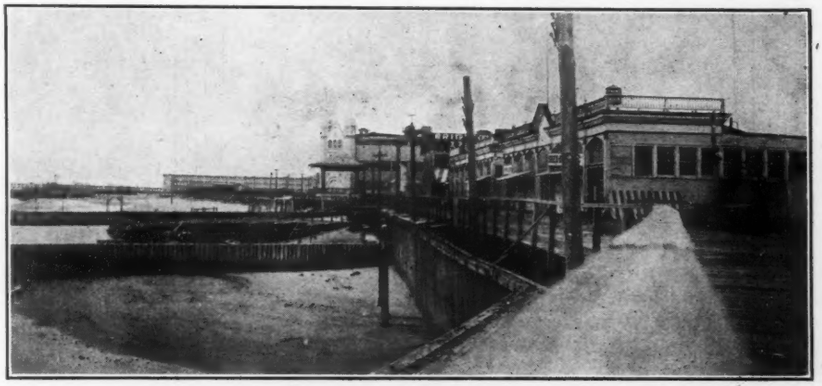
One can recall easily a variety of building operations along exposed coasts which are hampered, halted, or even damaged during the prevalence of stormy weather. A while back, a contractor notified Mr. Brasher that he was engaged in repairing jetties at one of our southern ports, and stated that his work was delayed about half of the time on account of rough seas. For the purpose of guiding the mariner, it is not infrequently necessary to rear lighthouses at places more or less continually swept by waves; and for the promotion of cemmerce permanent piers and breakwaters are indispensable at various points. In order to shield these structures during erection and to speed up their completion, a temporary air breakwater would be of conspicuous assistance. Again, dredges, employed in clearing navigable routes, are often forced to stop operations and to seek a haven until the return of fair weather, even though the movement of vital water-borne traffic is slowed up the while by a channel's insufficient depth or width. Here, likewise, a Brasher breakwater would neutralize Nature's unfavorable mood and hasten the consummation of the dredger's job. One outstanding virtue of this helpful, taming agency is that it offers no impediment to navigation—craft can travel freely above it.

A subaqueous air breakwater would quickly justify its cost: it would minimize the erosive action of the waves and enable bathers at resorts to revel in the water despite the prevalence of heavy seas beyond the invisible barrier. Breakwaters of this sort would answer far better in the long run and prove much more desirable than unsightly jetties that are expensive to build and apt to be wiped out by a single gale.

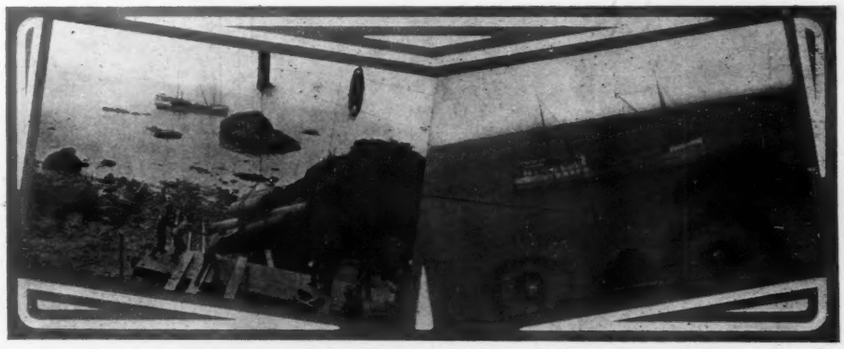
And now to return to the El Segundo installation. The plant which did such excellent service early in 1916, and which was in a measure experimental, has since been replaced, after a year's trial, by an improved equipment costing $50,000 and capable of providing an air wall totalling 700 feet in length. The advance section is 250 feet out from the pierhead and has a spread of 300 feet. At a point 250 feet in from the pierhead, and extending north and south from the wharf on each side for 100 feet, is a second bulwark; and 300 feet nearer the shore, there is another transverse pneumatic breakwater of the same span. The object of these three air barriers is not only to subdue oncoming waves but likewise to break up the ground swell, which often interferes with the loading and unloading of vessels exposed to it along the Pacific coast.

Finally, showing the force of example, a foreign oil concern is reported to have under advisement the placing of an extensive air breakwater of the Brasher pattern at a point on the south coast of England, where the Atlantic has a free sweep during the prevalence of certain winds. It may be remarked that other interests in the British Isles are seriously studying this type of protective medium as a substitute for the conventional breakwater or jetty of stone and concrete.

The world may yet have ample reason to rejoice that a shattered bulkhead, in 1901, set Mr. Brasher to pondering how smashing seas might be robbed of their destructive violence. Similarly, the pneumatic engineer should be gratified that the compressor can be relied upon to supply the needful disruptive energy.



Another example of a combination of jetties and bulkheads to save a beach and to fend off the gnawing surf.



Out on our northwest coast, at exposed places, vessels must load and unload while anchored off shore, using a cable conveyer to handle cargo. The photographs illustrate favorable conditions at both high and low water.

The exposed wharf at the Gloucester quarry during the prevalence of a strong easterly wind which made it impossible for vessels to lie there during loading and unloading.

Mining Millions of Tons of Iron Ore from the Great Open Pits of the Missabi Range.

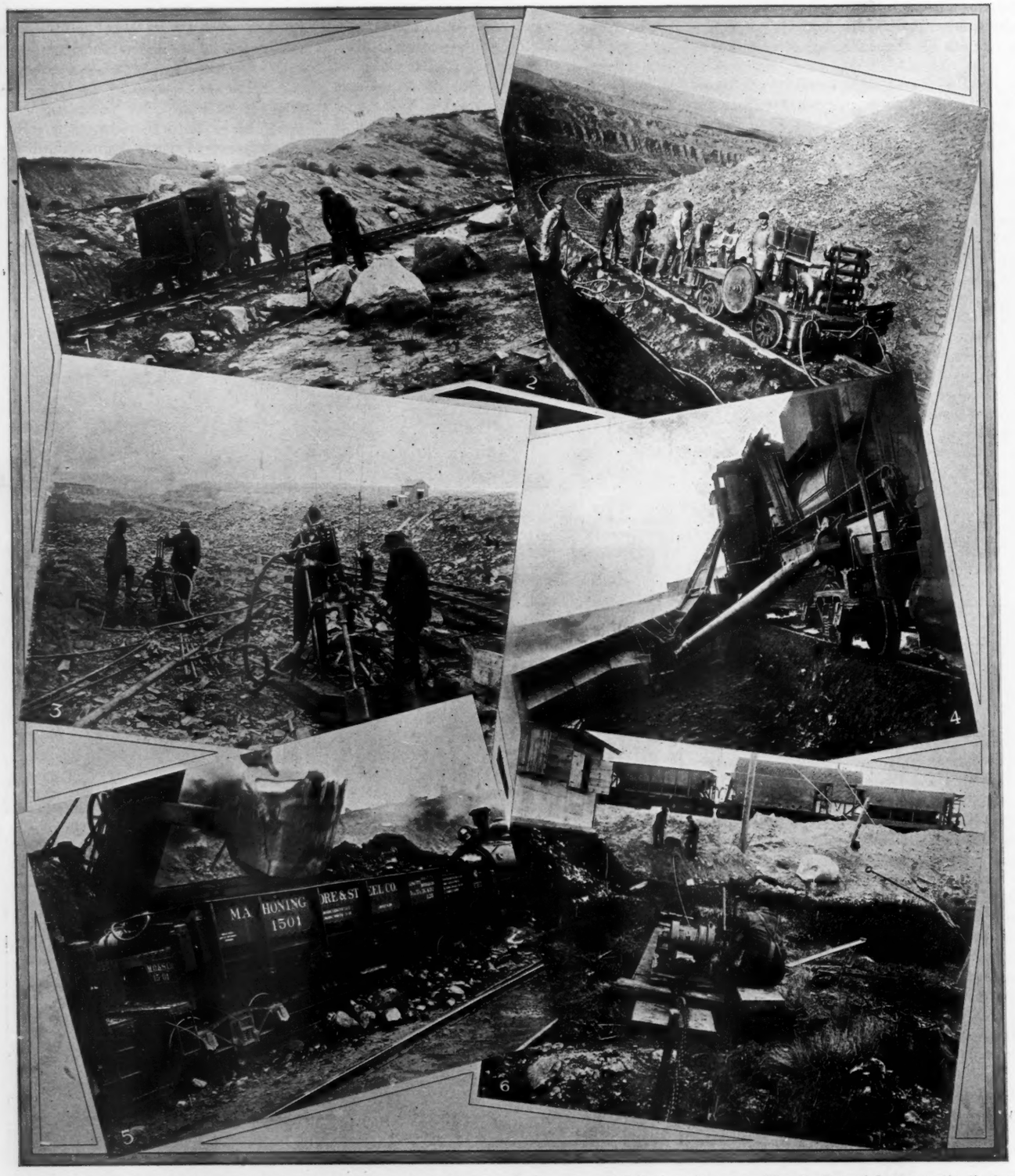


Fig. 1—Blockholing boulders with BCR 430 Jackhamer operated by air from Imperial tie tamping car. Fig. 2—Imperial pneumatic tie tamping machine gasoline driven. Fig. 3—D 113 piston drills putting down 26 ft. blast holes in overlying rock. Bench above track has been blasted. Fig. 4—Bucyrus spreader plow owned by Oliver Iron Mining Co. Fig. 5—Air dumped stripping cars, 910 cu. ft., 100,000 pounds capacity. Fig. 6—No. 11 grading peat bog around the buildings with Little Tugger hoist and "slusher."

Compressed Air On The Missabi Range

By "COUSIN JACK"

UP ON THE Missabi Range in Minnesota is the place they make the dirt fly. More cubic yards of Mother Earth are moved every year upon the Missabi Range then were moved in any one year upon the Panama Canal. Hills become holes and holes become hills, for the hills must be removed to win the ore underneath, and the spoil must be piled into other hills on ground not underlaid with ore. Some day—say a thousand years hence—when the ore is exhausted and the glory of the range a forgotten story, the professors of geology will have,—but what's all that got to do with Compressed Air? The professors of geology have enough speculating to do now without our speculating on their future speculations. Anyhow speculation belongs in the category of hot air; leave that to the geologists and promoters —compressed air is a mighty factor in moving the bowels of the earth on the Missabi Range and that is the story to be told here, and the machines that use compressed air as their motive power constitute the theme.

First comes the "tie tamper." The name is a mis-nomer. A portable, self-propelled, standard gauge, air compressor, driven by a gasoline engine, would smell as sweet by any other name,—when the curbureter gets out of whack—so let it go as a "tie tamper" for the machine was originally designed to furnish the compressed air for operating pneumatic tools that tamp the dirt under railway ties. Everybody has seen a section hand trying to poke ballast under a railroad tie when the track was being brought to a level. A more inefficient way of getting the ballast under the tie could not well be devised; but there was no other way until it occurred to some bright genius to do it with a pneumatic rammer. But what about the compressed air? Why not drive a little compressor with a gasoline engine and put it on a hand car? That's easy. Then why not make the engine propel the hand car when the compressor is not running? That is the story of the tie tamper.

Now up on the Missabi Range the dirt that goes from the holes to the hills has to be hauled over railroad tracks and both in the holes and on the hills these tracks are always on the go, like the dirt moved upon them, now here and now there. And the ties must be tamped and the track maintained for it is a serious matter to overturn a locomotive and send it and a train of dirt cars down a dump fifty feet high. Yes, that not infrequently happens because the ties were not properly tamped, and when it happens, please stay away and do not give any advice to the wrecking crew or you may meet large pieces of language interspersed with words not suitable for ears of the young person. A more generous use of the tie tamper would conserve strong language for which there are abundant other uses on the Missabi Range.

But in addition to driving the tie tamping tools the operators on the Range have found a lot of other uses to which this handy air compressor can be put. There is a steam shovel out in the pit that needs some repairs. Some rivets need to be driven. Bring a rivet forge and a pneumatic hammer from the shop and let's do the job where she stands. What the ———'s the use of hauling her to the shop when you can throw a rivet forge onto the tie tamper and do the work in the noon hour? Why not? "How the ——— did we ever get along without those blooming tie tampers?"

Well, so much for that. Let's look at the tie tamper from another angle. When the great ice cap or glacier came down from near the North Pole, shearing off the tops of mountains and filling up the valleys and changing the course of rivers, it pushed ahead of it great granite boulders and finally left some of them at its most southernly limit which the geologists call the "terminal moraine." But it dropped millions of them in the glacial debris which now overlies the deposits of ore. They are as big as cows, yes bigger, and they are in the road of the steam shovels and are as stubborn to move as cows in the road of an automobile, and more so. What are we going to do with them? "Send for the tie tamper and tell them to throw a couple Jackhamers in and we'll block hole the brutes."

"And while we've got the machine here we had better keep it and block hole a lot more before that track gang set up a holler and take it away from us. Why the ——— can't the company give us a tie tamper and a couple of jackhamers for every shovel." That's the kind of talk you'll hear on the Missabi Range where they have learned by experience the inestimable valve of compressed air as a promoter of efficiency in changing hills into holes. But that's enough for the tie tamper.

If you had visited the Missabi Range a few years ago you would have seen the dirt from the holes hauled to the hills in wooden cars, seven yards capacity, and dumped by placing a pole or "sprag" under the body of the car, and then causing it to dump its load by moving the train. This was not only a miserably poor mechanical contrivance for accomplishing the end, but it was a decidedly hazardous procedure. More than one skull has been cracked by being under such a car when it dumped. Why not dump the car by compressed air? The locomotive is equipped with an air pump to brake the train. Why should it not also dump the cars? Now go onto the Missabi Range and you will see trains of air dump cars of twenty cubic yard capacity—and 30 cubic yard cars are building—equipped with twenty inch diameter air cylinders, operated from the locomotive, dumping either in train or by individual car, as the conditions best warrant, and doing away with a very serious hazard, increasing the yardage per trip, reducing the labor required, and getting on and off the dump in a fraction of the time that was required before compressed air took the place of manual labor. Believe me, Maudie, compressed air is a wonderful dirt remover if you will apply it right. In the dirt moving game it beats a gang of "Dagoes" many a mile.

But by and by, this hill we are building out of a hole must be leveled down so that the tracks may be moved near enough to its edge that the dirt may roll down the side. And here is where the "spreader" comes in to do its share. The dirt has piled up alongside of the track until the cars can't dump any more. We must plow it down level so that the tracks can be moved over. For years crude wooden dump plows were used that pushed the dirt back a few feet and an army of laborers shoveled the rest, then came the "spreaders." Big, husky machines with a wing on each side that could be raised or lowered and a flanger in front, capable of being set to any height to plow the dirt off the track. But the wings, weighing tons each—for the dirt moving game is a he-man's job and things must be built "hell for strong"—must be set at different heights and different angles and the changes must be made with no delay for these shovels in the pit are digging right along and the stream of dirt must be kept flowing. That's the secret of moving dirt, keep the stream flowing. What power shall we use to operate a spreader? Compressed air, of course. Perhaps we could use steam but we have to have a locomotive to push her to her work and the locomotive has to have an air pump to operate brakes and the brakes are not in operation when the spreader is at work, so of course, the spreader is equipped with air cylinders for the performance of its different operations and no other motive power could do the work half so well. Believe me, Charley, when it comes to moving dirt on the Missabi Range where they think in millions of cubic yards, compressed air is the thing they fall back upon to help them out of their troubles, to speed up their work, to do the things that can't be done and keep the dirt moving.

Compressed air is great stuff. And did you ever think how much there is of it? All you need is a compressor and your raw material doesn't cost you anything.

The announcement that a through car from Boston, Mass., to Miama, Fla., will be put on the *Federal Express* which runs between Boston and Washington is the latest development in the use of the Pennsylvania Railroad's line into New York City. The through route furnished by tunnels under the North and East rivers and Manhattan, in conjunction with the Hell Gate Bridge line connecting Long Island with the mainland, is now used by four through trains each way daily.

A paper chimney, 50 feet high and fireproof, is a curiosity to be seen in Breslau.

Bessemer Beginnings

By FRANK RICHARDS

THE PLACING of the Bessemer bust in the McKinley memorial was an eminently fitting recognition of the life achievement of a supremely great specialist, a transformer and quickener of the civilized world's leading industry. Many of us realize, in a way, the revolutionary effect of the Bessemer process when first introduced, and the great changes which have followed, not only in iron and steel and all connected with the great industry, but also in the labyrinth of other activities apparently unrelated. A much smaller number in any way appreciate the greatness of the task which the inventor had before him when once the keynote of his invention had been struck, and the phenomenal resolution and resourcefulness which carried him to complete success.

To send a blast of air up through a mass of molten iron would seem to be a comparatively simple thing to think of, and it is not impossible that others may have thought as far as that only to at once dodge away from it. What would have been the use of following it up? What would be the effect, if any, of the blast upon the iron? It must have been quite problematical at first as to whether any effect produced would be beneficial or otherwise. The idea of a blast of air up through the iron was only the stating of a problem to be worked out by the inventor, with no suggestion as to its solution even if it were worth while, and if a complete plan could be devised it could not be tried out in a small way or by a little man.

At the very beginning, how should it be contrived to blow the air up through the iron? There were ways enough in which it could not be done, and the whole gamut of these could be run through the mind and successively discarded until the happy thought of the tilting converter came along, but even then it had to be tediously worked out as to its appurtenances.

And then as to the blast of air itself. The Bessemer process, by the way, was the opening of one of the great modern employments of compressed air, so a compressor had to be provided. This, as far as the machine was concerned, required little experiment except as to the volume and pressure required, but the demand was imperative for a copious and reliable and continuous supply.

As we were saying: even as an experiment, however crude, nothing could be done in a small way. There was no chance for hand work anywhere. For the quantities of iron to be handled and the precision and promptness required in the successive operations powerful hoists and conveyors had to be provided.

Thus, besides everything in the way of invention and preparation, the initial undertaking called for the expenditure, the sinking, of a large amount of money, so that only a man of wealth, or one capable of inspiring capital with sufficient confidence to venture in, could have won success. Imagination might have driven at the beginning but only nerve carried the thing through.

The realization of the greatness of the feat accomplished and the Herculean outfit of the man who accomplished it did not come to me all at once but had grown upon me. And indeed it is not possible to isolate the work of Bessemer from that of his co-workers and also his competitors and to apportion to each his share.

It happened that I was so situated as to know something of the beginning—or the near

Bust of Sir Henry Bessemer installed in the McKinley Memorial Building, Niles, Ohio. The inscription on the base reads as follows: Born January 19, 1813. Died March 15, 1898. His name is inseparably connected with the pneumatic process for the manufacture of steel.

beginning—of the Bessemer process in the United States. It was about 55 years ago that I was working at the Iron Works of the Starbuck Brothers, Troy, N. Y., and we were constantly working for the steel works from the very first, doing much original construction as well as repair work. All the ingot molds used were cast in the Starbuck foundry. I frequently saw Mr. A. L. Holley, the engineering head of the work, whom I remember as a strikingly handsome man, with most agreeable ways. I also remember Capt. R. W. Hunt, but saw him less frequently. Holley died prematurely and without attaining the engineering height he might have reached, while Captain Hunt has had a long career at a constantly high level.

My first visit to the Bessemer works in the early days of its operation was an event for me to remember all the days of my life. It worked a new point of departure for my thoughts in things mechanical. The plant was not a big one as such things go in these days, but there was a certain completeness of equipment to meet the special requirements and a perfection of co-operative functioning which was to me a revelation.

In the power house was the first air compressor of respectable size which I had ever seen; and in fact I do not know where I could have looked for another in those days. It was a horizontal, duplex, steam driven machine, built at the West Point Foundry, Cold Spring, N. Y. I was not capable of criticising or even of observing with accuracy in those days. The cylinders, as I now remember, were perhaps 48 in. in diameter and 60 in. stroke, and the movement was not rapid. As the air pressure never exceeded 15 lb., the heat of compression did not prevent proper cylinder lubrication, and as the heat in the air as delivered was desirable rather than otherwise, there was no water-jacketing. I do not remember the machine well in detail except that in the design of the bed-plate and other parts there was to me a new departure in the entire absence of all architectural or decorative effect, and rounded corners instead of sharp angles prevailed throughout. Everything was purely functional with no metal where it was of no use. The other important features of the power house were the pumps for the high operating pressure of the hydraulic service, the great accumulators for the maintenance of a steady flow to meet the suddenly fluctuating demand, and then the blowers for the cupolas. The entire power service was performed entirely by piping, and there was no line shift or other mechanical transmission. This was of course before the electrical era.

I was so fortunate as to see a complete "blow" soon after regular operations were under way. The converter room was a large open, high-roofed space with at one side of it a raised platform with handwheels and levers by which all operations were controlled. The most prominent object was the converter vessel and near it a large ladle or container, a pit with a number of vertical cast iron ingot molds and powerful hydraulic cranes which could be swung in either direction besides raising and lowering. Back of all were the cupolas for the initial melting of the innocent and unsophisticated cast iron.

At the beginning of operations the converter,

already heated, lay in what might be called its horizontal position with a pocket in the lower side of it to receive the charge of molten metal to be treated. I of course was at this time ignorant of the function of the refractory lining of the converter as affecting the character of the steel output, accepting it without question as only necessary for the protection of the converter shell, but here also persistent experimenting and invention had been involved, which we need not go into here.

The charge of molten metal was quickly run into the spout of the converter by a chute from the cupolas and immediately things began to move, nobody saying a word. The spout of the converter began to rise slowly and at the same time the blast of air began to roar up through the iron which flooded the perforated bottom of the vessel, and when it reached the vertical position the metal was distributed as a comparatively thin boiling mass all over the broad bottom of it, the blast of air having been increased in force and volume sufficiently to keep the metal from flowing down into the openings. The effect of the blast of air up through the iron was to set fire to it—as if it were but already hot enough—its carbon and some other constituents producing each a rush and volume of constantly charging flame and scintillation as to constitute the most brilliant pyrotechnic display that it is possible—or, rather, impossible—to imagine.

The turning of the converter to the vertical position had brought the mouth of it opposite a large opening in an uptake of sufficient capacity, so that the brilliant outrush was only partially seen, the body of it being carried out of sight.

The character and appearance of the discharge changed constantly, beginning quite modestly with a pale cone and some sparks, and then came a gradually increasing and intensifying flame which continued for two or three minutes, although the time seemed much longer, and then there was a sudden drop. The operation was watched with the keenest intentions by the "blower," and when the critical moment arrived the blow was ended, the converter was turned down and the blast was stopped. Then the vessel was turned still further down and its contents discharged into the big ladle. This was conveyed successively over the several ingot molds, filling each until the entire charge was disposed of. All of these operations followed each other without a moment's delay from first to last.

The blowing operation was assumed to have burned out most of the carbon from the cast iron, but not all of it, the portion of carbon remaining being the quantity required to give the iron its true steel characteristics. This threw great responsibility upon the blower for determining the critical moment, and some uncertainty remained as to the result. In a blow which I saw later the operation was continued until the decarbonization was practically completed, and then when the vessel had been turned down a precisely determined quantity of spiegelisen was run into the molten mass, thus giving a precise amount of carbon for the charge. The action of the diffusion of the carbon through the entire body must have been phenominally rapid, for the pouring of the metal and the casting of the ingots followed as rapidly as was mechanically possible and the steel was perfectly homogeneous.

All of this is an old and familiar story now, but a story which has been continuing ever since. The immediate success of the Bessemer process was only another beginning instead of an ending. It was after all only a pacemaker for allied and competing steel processes out of which has developed our modern industry now for the moment more or less complete until perhaps another surprise is sprung upon us.

Embarrassments and disappointments came along with the success. Here was hailed the ideal metal for the railroad, and Bessemer rails were prominently displayed at the Philadelphia Centennial, some of them polished all over and bent and twisted into most uncomfortable shapes, some of them tied into knots. I don't know how they did it. But, as we know, the first Bessemer rails did not wear well—or rather they wore too well—and were far from satisfactory. At the Troy works they tried to cast steel pinions for the Starbuck dredges, but the metal was so hot that it burned into the sand of the mold so that in some of the castings the teeth and the spaces ran into each other and they could not be used. So in various ways there was then still much more to be learned, and our education is going on.

COMPRESSED AIR USES IN THE REDUCTION OF COPPER*

IN THE REDUCTION of copper and the manufacture of acid compressed air is used on a large scale and in different modes of application. On account of its corrosive action acids cannot be pumped, and air does the work either by the air lift or by direct displacement, the latter without being largely used in the plant of the Tennessee Copper Company at Copperhill, Tenn.

This company operates three copper mines with four shafts within a few miles of the smelter and acid plant. This plant has a capacity of 1000 tons of 60 deg. sulphuric acid and 25 tons of copper ingots a day.

The processes for producing copper vary considerably according to the nature of the ore. The main ore deposit here consists of sulphides of iron and copper, and other metals in small amounts. A typical method of handling such ores is to mix them with coke and sand and heat the mixture in blasting furnaces. Loads of coke and ore are dumped into the top of the furnace which is kept in operation night and day. The air required for combustion enters through tuyeres near the bottom of the furnace. This is low-pressure air, with an average pressure of about 50 oz., and to supply it there are six blowing units with an appropriate average capacity of 217,500 cu. ft. of air per minute.

The chief function of the blast furnace is in the separating of the iron from the copper by burning iron sulphide to sulphur dioxide and iron oxide, causing the latter to unite with the sand to form iron silicate, commonly known as slag, which is drawn off and rejected. The copper sulphide, together with some iron sulphide, melts and concentrates at the bottom of the furnace. This "matte," as it is called, is then poured into a converter. In the converter a blast of air is forced through it to burn out sulphur and leave the crude metal known as blister copper. This blister copper is about 96 per cent pure and is later refined by electrolysis.

The air pressure required for the converter is 15 lb. and there are three blowers having a combined capacity of 35,000 cu. ft. of air per minute. These blowers comprise two cross-compound steam engines direct connected to single stage duplex air cylinders with a capacity of 10,000 cu. ft. a minute each. The steam cylinders are 15 and 30 by 42 in. and the air cylinders 40 and 40 by 42 in. The third unit is a blower, with a capacity of 15,000 cu. ft. per minute, driven by a 972 h.p. synchronous motor.

For the transfer and manipulation of the sulphuric acid, which is an important item of the output of this plant, compressed air at high pressure, 120 lb., is employed. Included in the compressor or equipment for this service is an Ingersoll-Rand, class PRE two-stage machine 16½ and 28 by 21 in. at 200 r.p.m., driven by a synchronous motor rated at 458 h.p. There is also a duplicate unit speeded at 180 r.p.m. and the motor rated at 438 h.p. The other high pressure units consist of an Ingersoll-Rand single-stage steam driven compressor 16 and 17½ by 24 in., an Ingersoll-Rand two stage compressed steam driven compressor, 12 and 22½, 14½ and 21 in.; an Ingersoll-Rand 28 and 18⅛ by 24 in. and a smaller unit 10 and 6¼ by 10 in., both driven by induction motors, and two Ingersoll-Rand steam driven compressors 12, 12½ and 18 by 12 in., eight compressors in all for the high pressure air.

*Condensed from "Southern Engineer."

TO FIND WHAT'S IN AN ENGINEER

"Who has the ability to tell a good story?" That is one of the queries the New York Chapter of the American Association of Engineers is addressing to its members. It is trying to evaluate the abilities of each of its members by asking them to designate men excelling in various qualities. Other questions are: What engineer has the most attractive personality? Who is the best all-round engineer? Who can describe an engineering work most thoroughly and concisely? Who can make the best address of welcome? Who has musical ability? Who is the most interested in athletics and can organize athletic teams? Who is a good man for committee work?

The Foreign Commerce Department of the Chamber of Commerce reports that the exports of wheat in September, 1920, were 30,750,000 bushels against 17,000,000 for September, 1919, and the exports of flour for this same month were only 938,000 barrels in September a year ago.

The Uses of Compressed Air in the Modern Submarine—II

The Future of the Submersible Type of Ship and the Vital Part Compressed Air Must Play in its Development—America Lagging in Progress

By CAPT. YATES STIRLING, JR., U. S. N.

THE SUBMARINE is the most dreaded of all the weapons of naval warfare. It is so, for the reason that man fears most the dangers he may not see. It is more dreaded than the mine because unlike the mine it is controlled by a highly trained intelligence and operated by a thoroughly drilled and coördinated crew. Like other types of warship, unless it is so controlled and operated, it is of no avail; without experienced personnel a submarine is a dead thing, a possible coffin for its crew. A surface ship may navigate the sea with a certain degree of safety even though its crew is untried, but a submarine diving beneath the surface with an untried crew is a thing unheard of, except when made necessary by the direst straits. We have learned that Germany was forced to send against the Allies many submarines with untried crews. Trained crews became scarce after the allies organized and got going their anti-submarine offensive, taking heavy toll of the U-Boats. We cannot know for certain, but we can make a fairly accurate guess as to the number of vessels she lost through accidents due to inexperienced crews.

We have the records of the British Admiralty giving the cases of certain sinkings of U-boats and Germany has told us how many of her submarines were never heard from again. Comparing these figures and making due allowance for cases where the submarine may have been sunk by enemy action, it seems fair to suppose that half a hundred U-boats were lost through accidents that might have been avoided with a well trained crew. It is said that Great Britain and France both lost a considerable number of submarines through accident due to either untried personnel or faulty material. Such things must always happen in war, yet it is our duty in peace to insure that these accidents will be kept at a minimum.

Many authorities predict the coming importance of the submarine. Admiral Sir Percy Scott and Admiral Viscount Beatty are quoted to have stated that even a submarine battle cruiser is not beyond the bounds of probability. At all events the world, having grown tired of the monotony of the surface of the sea upon which it has sailed and fought for centuries on end, is now more than gazing with fascinated eyes both under the sea and in the air.

These two mediums are comparatively new and their possibilities seem almost limitless. The surface warships have evolved to tremendous size, carrying guns so large and of such range that the control of their fire cannot be accomplished from on board the ship. The necessity has come to control these guns from airplanes flying at great heights above the enemy and telephoning without wires down to the firing ship to correct the range to hit the target. Only the top of the masts and the tip of the smoke stacks are visible to the gun layers upon the firing ships.

So complete has been the development of surface warships there can be no surprise that nations are seeking an easier and less expensive means of increasing their sea power. Germany became after 1914 wedded to the submarine. That the weapon failed her was no fault of the submarine. It did things that startled the world, and now all nations interested in the sea are engrossed in studying the possibilities of the weapon. Not for the purpose of replacing the battleship but to outweigh whatever advantage a possible rival may have in battleship strength.

The nation with the most efficient and numerous submarine force, comprising vessels of seakeeping types, will be a very dangerous enemy for another nation to attack. The United States with her long coastline and her vital interest in the sea cannot afford to neglect this weapon. The entire navy is at present suffering from the effects of the recent war upon the civil population. The nation is like a man who having just finished a hearty dinner is asked what he wants for supper. His answer is "nothing"; yet when dinner time comes he is most surprised should there be nothing to eat.

This interregnum before the nation again interests itself in the means of defense must not be entirely lost. The General Staff of our next enemy may be keeping itself informed of our unpreparedness and quietly and silently preparing its navy for a conflict with ours.

Very few appreciate that the operation of a submarine in both peace and war is more difficult and attended with greater risks than an airplane or a dirigible. So wedded are we to the opposite conviction that "fliers" in both the army and navy are paid 50% additional pay for flying while the officers in our submarines are given no additional pay for this duty, and the enlisted men are paid one dollar a dive limited to a maximum for all ratings of a paltry $15 a month extra pay.

All who have flown know how very simple flying really is. Hundreds of thousands were trained in Europe and this country during the war. The pilot has all in his own hands. He guides his machine up or down, banks, spirals and turns, using levers and wheels all within the reach of his hands or feet, and also for the sake of greater security these "controls" are duplicated and a second flier at his elbow or in rear of him can correct a mistake or take over the control in case of accident to the pilot.

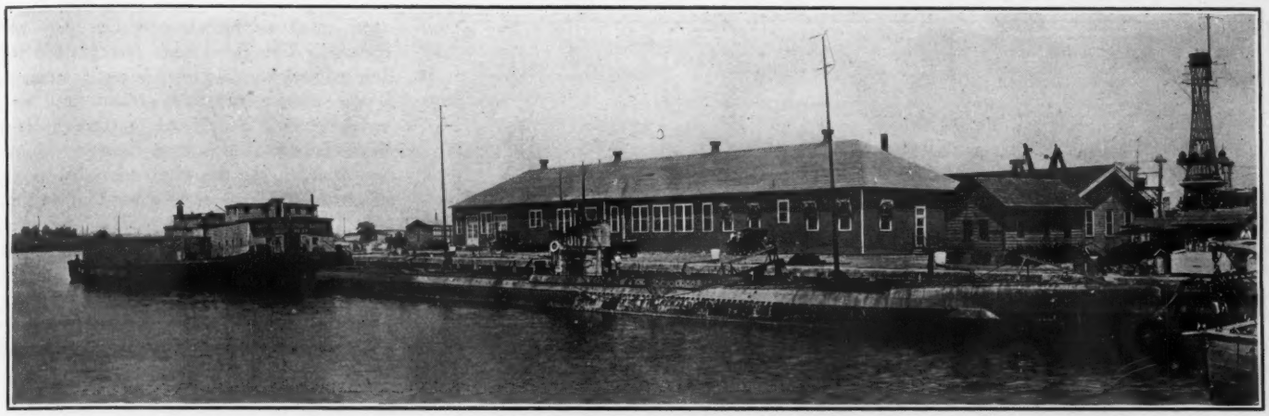
An aircraft can leave the ground and soar into the blue until the rarity of the atmosphere forbids further ascent. This height is reached at something over 20,000 feet. There is no air pressure to avoid which might crush the frail craft. A fall upon the earth is the one danger and this danger decreases the higher the machine is up. The air at 500 feet has no more terror to the aviator than the air at the highest point possible for him to reach, except he be overcome by too quick an ascent.

How different it all is with the submarine. It operates in a medium that weighs about 64 pounds to the cubic foot. Every foot it goes beneath the surface the water pressure increases one-half pound upon each square inch of surface of the vessel. At 300 feet therefore the pressure is nearly 150 pounds per square inch. Shell plating to stand such pressure must be built very strong. It has been claimed that the German submarines could withstand a crushing pressure corresponding to this depth. Those built in this country are tested at a pressure considerably less. Two hundred feet is considered the safe maximum; to go deeper than that is attended with great danger to the structure of the boat.

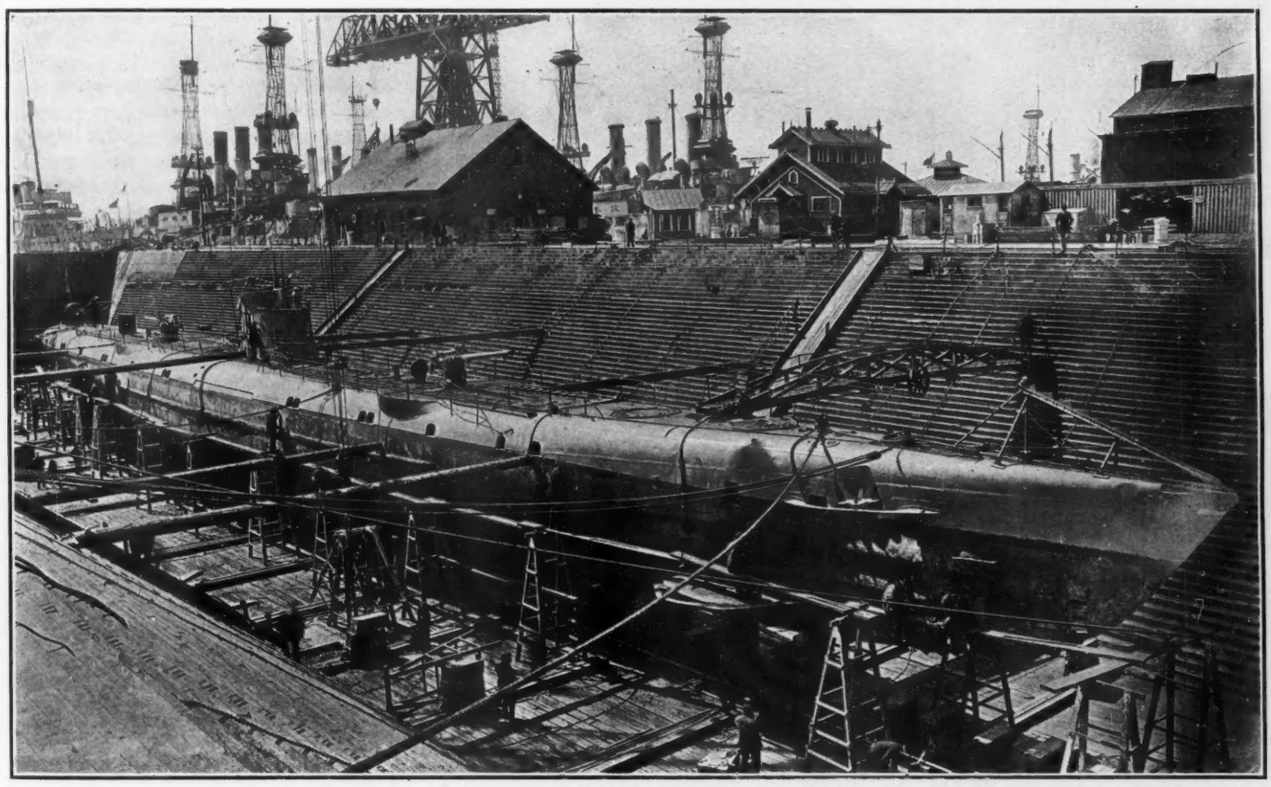
The crew of a submarine of course varies with the size; the small coastal type carry a crew of about twenty men. The S-5 when she made her fatal dive had on board thirty-four persons, including four officers. The large German submarine cruisers, like the U-140, carried five officers and nearly eighty men. These crews must be coördinated to act promptly and accurately. One man's mistake may cause a disaster. The submarine captain, unlike the pilot of an airship, has *not* all the controls within reach of his hand, and yet upon his knowledge, experience, judgment and skill hangs the safety of all his men and the vessel itself.

The aircraft starts its engine and soars aloft. The submarine captain has no such easy job and his responsibility is much vaster. He sounds his alarm signal for a "crash" dive. This is the dive made in war time to escape beneath the surface or to avoid detection should an enemy ship suddenly appear. In a submarine of the type of the U-140, 80 odd men must immediately, within seconds of time, perform operations to change the character of their ship from a surface vessel to one that can dive beneath the surface. Every opening in the vessel must be instantly closed, for upon sounding the alarm the air vents to all ballast tanks are opened and water begins to flow through the big Kingston valves and fill the ballast tanks.

The submarine at once starts to settle and should one opening be overlooked the entrance of sea water into the vessel itself may prove disastrous. The openings that must be closed include the following:—Engine exhausts, ventilator ducts, all hatches, and all valves controlling water from overboard to tanks which may not be built to withstand the water pressure



The U-117, a combination of torpedo, gun and mine "Viper." She is about 265 feet long and 27 feet beam and has two engines of 1800 h.p. each. This type has a surface speed of eighteen knots, carries fifteen torpedoes, 30 mines and has a battery of two 5.9 inch guns. The submarine shown above was the one that laid mines off the United States coast and sank several ships.



The U-111, a smaller type of submarine that was not equipped for mine laying.

at the depth to which the vessel may go. Then motors must be started and diving rudders manned to steer the boat under the water. The air manifolds are manned to be prepared to blow water from any tank in order to adjust the trim or to bring the boat to the surface in the event that something has gone wrong. Once under water the vessel must be steered to a depth where it will be safe from surface ships hunting it yet not too deep to have its sides crushed by the water pressure. The submarine must operate between the surface and about 200 feet depth.

The U-140 is about 300 feet long, so the constant guiding of the vessel within this narrow lane of water is not easy. To have its hull safe from contact with the bottoms of surface ships, it must go to a depth of over fifty feet, usually for greater safety against the use of depth bombs from aircraft or destroyers it will venture to 100 or even 150 feet. At this running depth there is but little to spare. An inclination of ten or twenty degrees by the head or stern may place that part of the vessel under crushing pressure or at least give the hull sufficient pressure to start leaks in the hull.

This was the reason the Germans made every effort to build their U-boats strong enough to withstand pressures which seemed impossible to us. There is an authentic record of a U-boat diving to a depth of over 300 feet to escape from the depth charges of a persistent American destroyer.

The sealing up and diving of the submarine is not the single act of one man but the coördinated acts of many men. Once under water and determined to attack a surface vessel, the submarine must be guided toward the surface to a depth where the periscope can be used. The captain claims the use of the submarine's eye; looking through the periscope he directs the steering both horizontal and vertical to enable it to fire its torpedoes with accurate aim. The periscope is the gun sight of the torpedo. During the hours under water the captain through his trained crew must constantly watch the condition of his vessel's trim and direct the men at the air manifolds to blow water out here or admit water there and the men who obey his commands are not always immediately under his eye for some may be at a distance of over a hundred feet. An error or an oversight of one man may destroy his ship and drown his entire crew.

This is the naval weapon of war in its modern form invented by an American but devel-

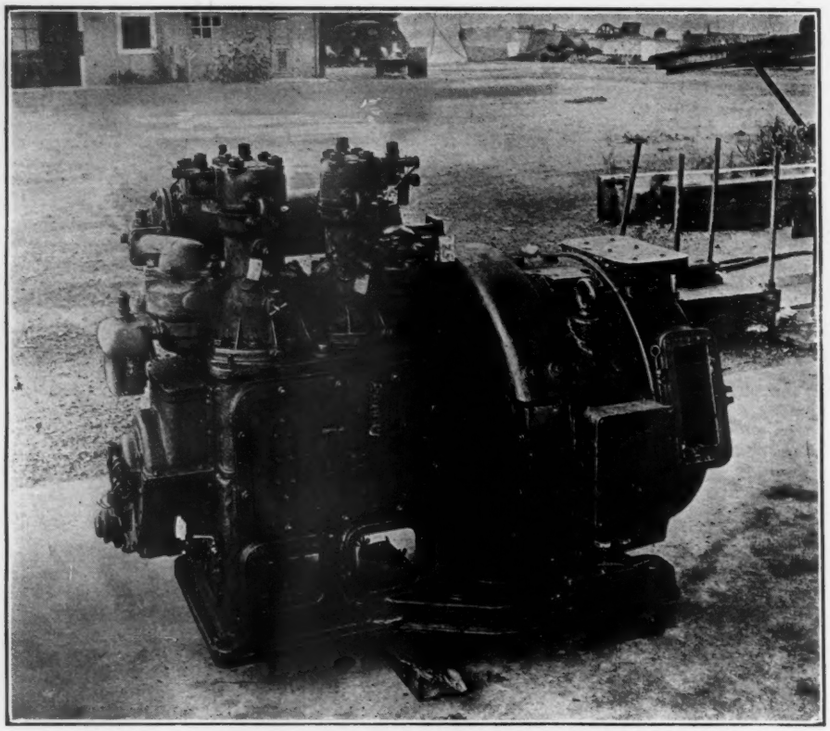


Fig. 1—Inboard view of air compressor from ex-German submarine U-148.

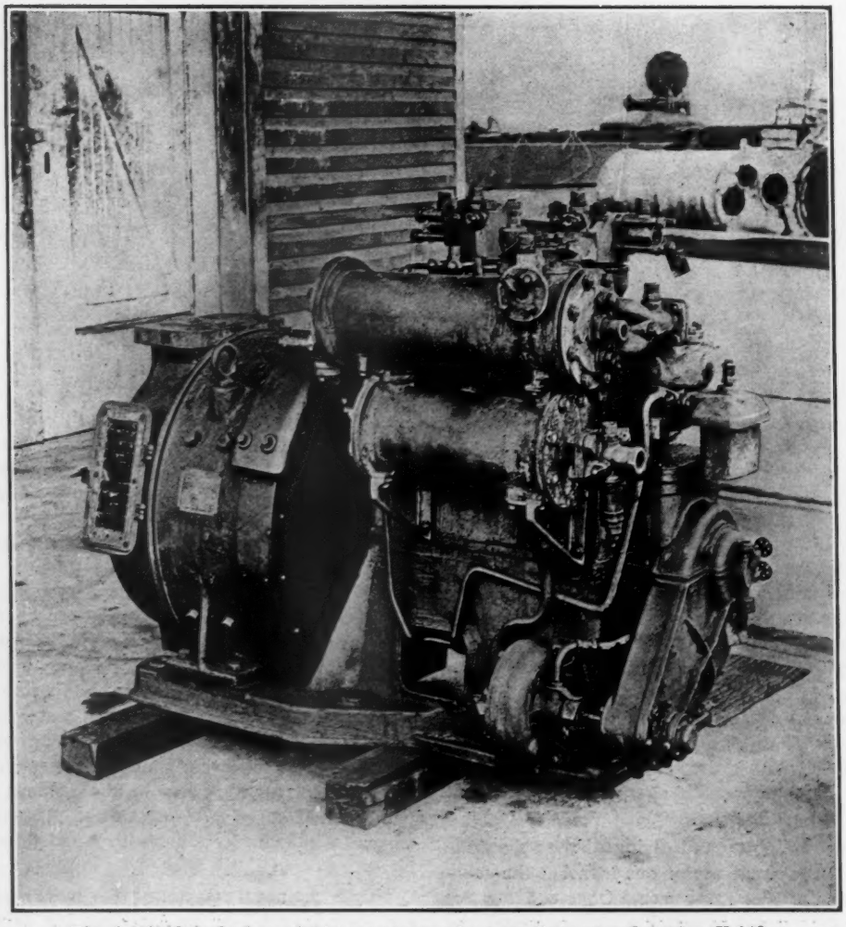


Fig. 2—Outboard view of air compressor from ex-German submarine U-148.

oped most artfully by the Germans and the British. The Americans have failed to hold the lead which the inventor put in their hands. They seemed content to follow and unfortunately not too closely the foreign navies in the development of this type of ship. Some day we shall *all* see the vital necessity of a most efficient submarine service but that day may be too late to correct our errors. The men who are operating these vessels side by side with the aircraft see the sister service paid an increased wage to operate a weapon that they know is not half as dangerous to life as the craft they are operating. This cannot add to the morale of the submarine personnel.

At the commencement of the world war Germany owned only the small type of U-boat, of about 500 tons, similar to our K class. There were a few larger vessels on the stocks. Before the war the nations of the world gave little consideration to the possible destructiveness of the submarine. Many high ranking naval officers spoke of them as expensive toys. Sir Percy Scott was the mouthpiece of progressive naval thought that saw in this type a very formidable weapon. Most naval men thought of them if they thought of them at all as sea moles with inaccurate weapons and of little menace to a wide awake surface ship. They were sure that the destroyer could run them down and sink them.

The sinking of the three British armored cruisers by one submarine gave Germany her "hunch" that possibly the world had underrated the submarine. Her High Sea Fleet was no match for the fleet of England. The U-boat was seen as a God given weapon to deliver the mistress of the sea into her hands. How nearly this was an accomplished fact England now knows only too well, and will never be caught napping again.

Germany developed her U-boats feverishly and their execution on the sea was appalling. The word "submarine" caused the face of the bravest to blanch when heard in alarm on the high sea on board surface ships. The size of the submarine and its radius of action mounted month by month as the war went on. The tip of the curve of development just as the armistice was signed reached to 3000 tons displacement. Such vessels were found uncompleted on the stocks in the German shipyards. The U-140 type of about 2300 tons was already in commission and had been tried out but had not proved entirely satisfactory. The German crews were not as expert as formerly and this may have contributed to its failure. The trouble seemed to have been with the balance of these boats and they were returned to the shipyards for re-ballasting.

The U-117 type of about 1800 tons was in active service and did effective work on our coast against merchant shipping and in mine laying. The largest Deisel engine for submarine use was of about 2500 horsepower; two such engines would give the larger submarine cruiser a surface speed of about 18 knots. These super-submarines had a length of over 350 feet and carried a crew of nearly a hundred men. Their radius of action was upwards of 15,000 miles, without refueling. They mounted as did the U-117 and U-140, two high

power 5.9-inch guns and carried four 22-inch torpedo tubes and 30 torpedoes.

A vessel of the U-140 type is now in one of our own dock yards being pulled apart and studied by our submarine officers and men. It will be destroyed in conformity with an agreement made by the Allies when these vessels were divided up among the victors. The U-140 was a match for any destroyer. Thus far in their studies our officers have found the German submarines a marvel of design and workmanship. They pronounce them as complete as seems possible and declare that the Germans were far ahead of us in nearly all the important details. The completeness and the splendid workmanship of these vessels exemplifies what a patriotic industrial nation can accomplish when faced with a dire necessity. It seems almost miraculous that with such vessels Germany could lose the war on the sea.

A nation with half a hundred cruisers of the type of the U-140 or larger with crews thoroughly trained and actuated with the highest spirit of patriotism could so seriously dislocate the arteries of trade that an enemy would be hard pressed to keep open its lines of communication. Napoleon said that war is a business of position. He never risked a serious battle where he could instead cut the lines of communication of the army opposing him and force it to retreat. Many have wondered why Germany did not use her marvelous submarines against the Grand Fleet instead of sending them against merchant ships. The answer is contained in the words of Napoleon.

Germany was certain that the unrestricted submarine warfare would in the end cut England's lines of communication and prevent the necessary sinews of war from reaching her hated antagonist. Without food the British could not have continued the war. Without oil the British fleet could not have been ready to fight the High Sea Fleet. Without American men and supplies the armies on land would have been overwhelmed by the German hordes. The material was not lacking for this accomplishment, the submarines we are studying prove that point and when the armistice was signed Germany owned some three hundred of the most modern types. The people of Germany lost confidence in their leaders, they no longer believed them infallible and the pinch of the Allied blockade had weakened the stamina of the civil population. Germany has bequeathed to her enemies the weapon with which she had hoped to win the war.

We no longer despise it and most naval men fully realize the great part it must play in the next war. Japan we are told has nearly a score of these German submarines commissioned in its navy and is training crews for them under the guidance of German naval officers. What a menace a hundred submarines would be in the Pacific unless we held the antidote—a hundred vessels of an equal or superior type.

If there had been no war, submarine tonnage today probably would not be very much greater than it was in 1914. A rise from about 500 tons to 3000 tons in less than five years seems a prodigious increase—600%. Before the war the nations treated the idea of the submarine with almost contempt. Their weapon, the torpedo was thought inaccurate except at very close range, and the destroyer was believed capable of settling them before they could endanger the big surface ship. Ask the same nations today.

The best brains of the world have been at work devising means of defeating the submarine. Listening devices perfected at great expense have been installed in many types of fast surface ships for the purpose of hearing and locating a submerged vessel in the vicinity and continuously following it to its destruction. The best of these devices discover the presence of a submarine as reliably as an untrained ear can detect the song of a canary in a boiler shop.

The depth charge is a formidable weapon but unless the submarine is accurately located it requires hundreds of charges to be certain of one hit. Many submarines have been reported sunk by depth charge that afterwards turned up in Germany very little the worst for their encounter. Few actual cases of sinking by depth charge have been recorded and the number of depth charges dropped has been in the thousands. It is said that it requires a man's weight in bullets to kill him. It would appear that this holds true also for the depth charge.

The submarine above all other sea weapons is most dependent upon perfect material. This is true not alone for operation but on account of the difficulty of making repairs at sea. The best drilled submarine personnel cannot long keep its vessel in efficient condition should the material making up the vessel be faulty.

If we stop and count all the intricate and vital machines installed in a submarine we will conclude that a flaw in any one of them not alone weakens the chain but actually breaks it. Efficient operation depends equally upon each. The submarine's power is, to speak in terms of mathematics, the product of all the factors involved, therefore one being zero the product becomes zero.

The Deisel engine is the source of all power. Reliability, speed, swiftness and facility for overhaul are all very vital. Faulty lubricating and cooling systems causing burned out bearings, cracked cylinders and pistons must be absolutely eradicated. Not only must the design of the engine be faultless but the workmanship as near perfection as is possible to make it. Spare parts of machinery must be so accurately made that they will slip into place a perfect fit without machining. A serious accident to the engines reduces the submarine to a helpless hulk.

A storage battery so badly designed or constructed as not to stand up under constant and hard usage or a motor whose installation is faulty or whose bearings frequently burn out cannot be permitted space in a submarine; the junk pile is the place for such material.

Air purification, periscopes, ventilation, diving and steering motors, listening devices, pumps, air compressors, hatches, etc., each are functions of the product. The crew cannot live long beneath the surface if the air purification fails. The captain cannot see to attack or escape if the periscopes are dim and vision uncertain. Ventilation must be at all times adequate to dissipate foul air and prevent the accumulation of inflammable gases. A breakdown of diving gear or steering gear might instantly jeopardize the safety of the vessel. Listening devices so useless to a surface vessel are of primary importance to the submarine. The reason is simple for under water there are no surface noises for the device to eliminate. Noises made by the surface vessel are so much greater in magnitude than the single noise, that of the submarine, that wonderful expertness is required to select the one

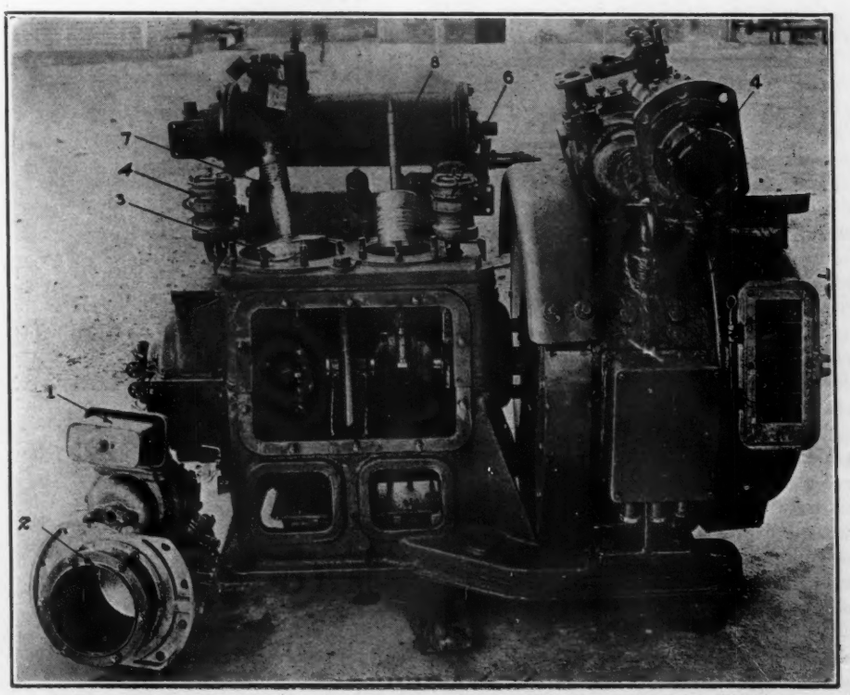


Fig. 3—Inboard view of air compressor from ex-German submarine U-148.

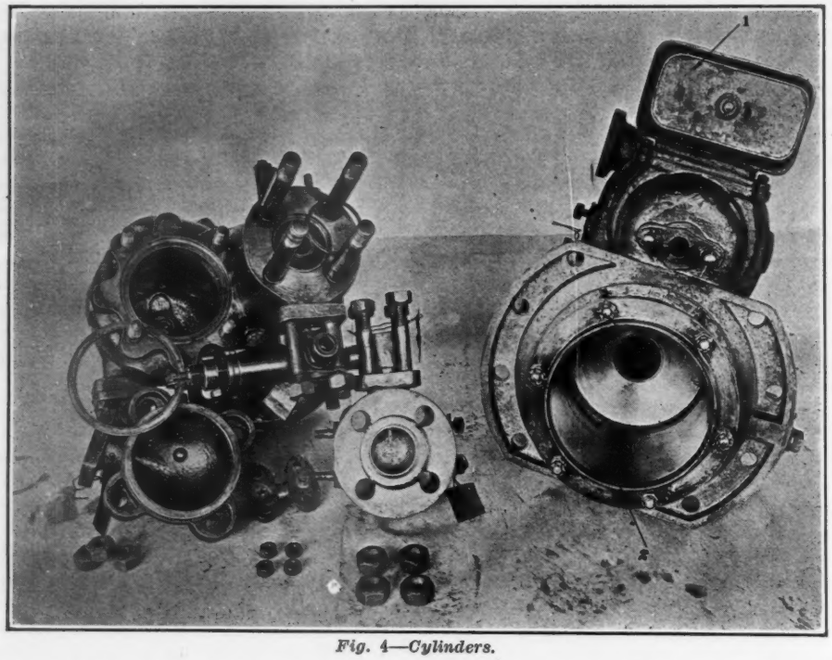


Fig. 4—Cylinders.

noise desired from all the rest. The submarine running silently on its motors beneath the surface is able to hear the propeller noises of surface vessels at considerable distances and thus can avoid its enemies without exposing itself to attack. Therefore the best listening devices are none too good.

The personnel is an important factor. The most perfect material will not long remain perfect in the hands of incompetent or careless men. But of all the vital things compressed air is the most vital for it is the blood of the submarine. Without it the submarine dare not submerge. If compressed air is the blood then the air compressor is the heart and the perfection of this machine becomes of supreme importance in the development of this type of warship.

The German submarine lived through four years of warfare when every minute the surface of the sea was in the hands of its enemies. That domineering nation knew that to have a chance to win against the seapower of her enemies she must concentrate all effort upon the perfection of the submarine. The aim was to make each machine as near perfect as the painstaking character of their workmen would permit. Now that the war is over we have been privileged to study their latest and most perfect vessels. Each machine has been found to have been designed and built with the care that a watchmaker puts upon a delicate and intricate watch.

The personnel of the U-boat was protected at every turn with a machine as near perfect as German industry could make it. How did this come about? By a close coördination between designers and operators. When a submarine returned to its base the designers came on board and talked with the operators. The latter's lives depended upon the concrete results of those talks and explanations. A very short interval was permitted to elapse between the discovery of faulty gear and the remedy in improved machines.

This close contact between designers and operators is of vast and vital importance. Unfortunately too long a time is allowed to elapse in time of peace between the knowledge of the cause of accidents and the design to correct them. This looseness or play gives rise to the use of what are termed 'gadgets,' which do not correct the fault but merely lessen the evil of it.

The German air compressor was no exception to other machines evolved during four nerve racking years of war. A study of this machine may help us to perfect the design of those "made in America." We never will acknowledge that what bears the above trade mark is second to anything. But is it not wise in our own conscience to make certain that we are not fooling ourselves, for victory in war will depend in no small part upon the perfection of our material?

The air compressor shown in the photographs, is one installed in a German submarine mine layer of about 500 tons displacement. It is the last word from Germany for since this one was built she has had no need to develop further submarine air compressors.

The compressor is single acting and has four stages. The first and third stages are on the bottom and top respectively of the stepped piston further from the motor and the second and fourth stages on the bottom and top of the stepped piston next to the motor. (Figures 1, 2, and 3.) The air coolers are located on the outboard side of the compressor as installed in the vessel; the upper cooler contains the first and fourth stage coils and the lower cooler the second and third stage coils. A water relief valve is secured to each cooler body and relief valves and thermometer wells attached to each stage. The first and second stages have their valves located in valve chests cast "en bloc" with cylinders (Fig. 1) and the third and fourth stage valves are located in the removable heads (Fig. 3). Lubrication is furnished by a small rotary pump direct driven on the end of the crank shaft (Fig. 1).

Circulating water for jackets and coolers is furnished by a centrifugal pump secured to casing on the outboard side as installed in the

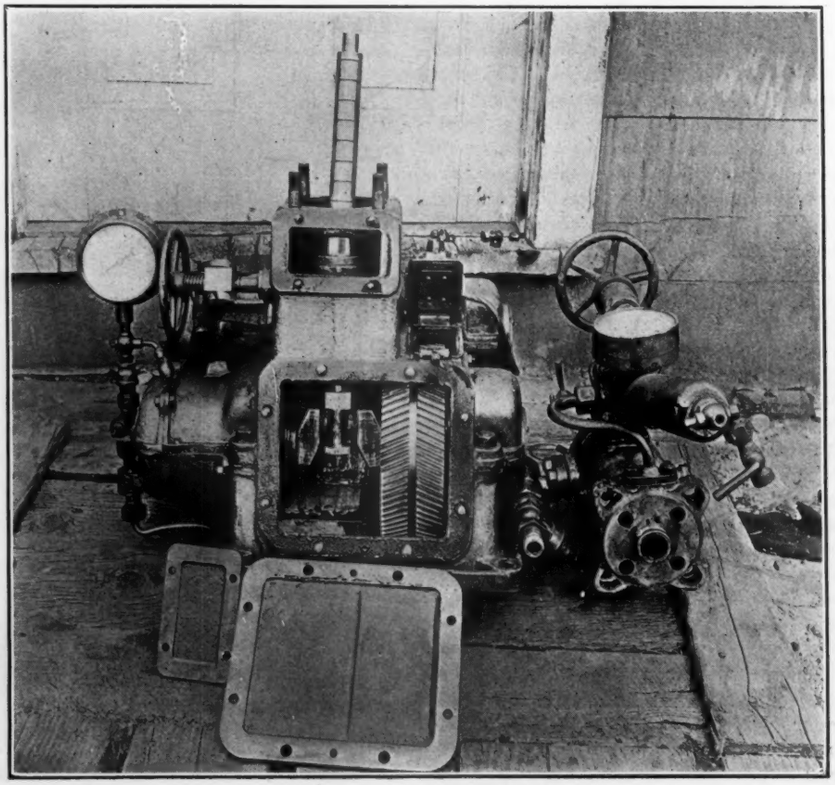


Fig. 5—Booster compressor.

vessel and driven from the crank shaft by a chain and sprockets. The power for driving the compressor is secured by a direct connected direct current motor.

The compressor is capable of compressing 8.47 cu. ft. per hour to 2272 lbs. per sq. in. The pressures in each stage are: 1st—28 lbs., 2nd —113 lbs., 3rd—572 lbs., 4th—2272 lbs. The revolutions of the compressor vary between 560 and 650 as the voltage applied to the motor varies between 110 and 170. The electrical horsepower of the motor is from 21 to 27 adapted to voltages between the above figures at an amperage between 168 and 134 at a speed of 560-650 revolutions. The machine is very compact and light in weight. All parts are readily accessible; an important point in making repairs with the ship's force.

The material and workmanship appear to be of the best quality, each part is made of the material best adapted for its purpose and accurate fits made where necessary for economy and smoothness of operation. The compressor requires but little attention and adjustment. The pistons are self aligning. It is done by means of the ball and socket joints instead of the usual practice of wrist pins. Cylinders and valve liners are easily removed.

	Cylinder diameters	*Piston diameters*	*Piston clearances*
1st	stage 6.458″	6.455″	0.003″
2nd	stage 3.703″	3.696″	0.007″
3rd	stage 1.975″	1.965″	0.010″
4th	stage 0.948″	0.947″	0.001″

Stroke, 3.907″. Travel of piston valves, 1.062″. Height, 3 ft. 6 in. Length, 4 ft. 10 in. Width, 3 ft. 0 in.

The motor bedplate and compressor bedplate are one casting.

Travel of air through the compressor is shown by Figs. 1, 2, 3 and 4.

The air is drawn from the atmosphere through the 1st stage intake (1), and the 1st stage valve chest and valve into the 1st stage cylinder (8). Fig. 3 shows the 1st stage valve in place with cylinder removed. The 2nd stage piston valve is of the same type as the 1st stage valve. As the 1st stage piston (4) moves down, the lower or suction ports are uncovered by the piston valve (2). On the up stroke of the 1st stage piston the suction ports are closed or covered by the valve and the air in the 1st stage cylinder is compressed until the piston reaches the top of its stroke when the upper or discharge ports are opened. The air is then forced through these through a disk valve located in the top of valve chest into the 1st stage cooling coils. The cranks are set 180 degrees apart and the air is forced through lower or suction ports of the 2nd stage valve into the 2nd stage cylinder (27).

The action of the 2nd stage suction and discharge valves (3) is the same as the 1st stage valves. On the up stroke of the 2nd stage piston the air is compressed and forced into the 2nd stage cooling coils. The 3rd stage piston (5) is now at the bottom of its stroke and the air from cooling coils is forced through the ball check suction valve into the 3rd stage cylinder. On the up stroke of the 3rd stage piston (5) the air is compressed and forced through the 3rd stage discharge valve into the 3rd stage cooling coils. The 4th stage piston (6) is at the bottom of its stroke and the air is forced through the ball check suction valve into the 4th stage cylinder. On the up stroke of the 4th stage piston the air is compressed and forced through the discharge valve into the 4th stage cooling coils and thence into air bottle storage for ship's air supply or through air lines to torpedoes.

Figs. 1 and 2 show the machine assembled.

Fig. 3 shows the machine with cylinders removed exposing the stepped pistons. Figure 4 shows end views of these cylinders.

Figs. 5 and 6 show a booster compressor which is used to boost up a charge in an air flash or torpedo. It is in fact the fourth stage of a compressor.

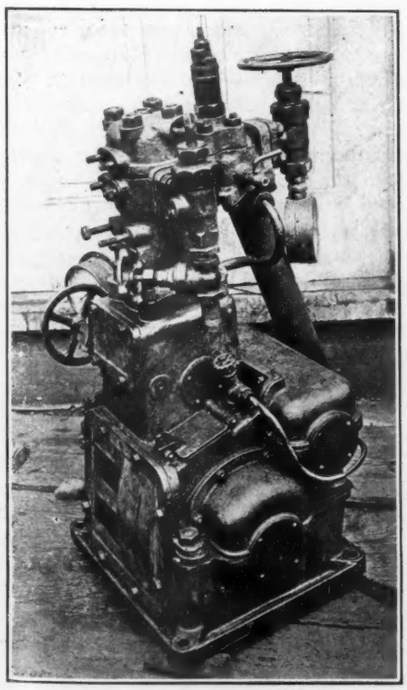


Fig. 6—Booster compressor used to boost up charge in air craft.

GERMAN COAL OUTPUT FROM JANUARY TO AUGUST, 1920

The coal output of Germany, disregarding Alsace-Lorraine, the Saar district and the Palatinate, amounted in the first eight months of 1920 to 84,190,000 of tons compared with 67,800,000 tons during the same period of the year previous; that is an increase of 16,390,000 tons or of about a quarter (24.18%) of the output during the same months of 1919. The figures for lignite showed a smaller increase; with an output of 71,090,000 of tons the increase was 16,980,000 or 18.94%. The production of coke amounted to 16,080,000 of tons being an increase of 270,000 or 20.19%. About the same increase showed the working of briqueting coal. The output of briquets was 3,110,000 of tons being an increase of 545,000 tons or 21.24%; lignite briquets at an output of 15,450,000 of tons showed an increase of 2,760,000 or 21.80%.

Up to October 15 last, 107 ships built at Hog Island by the American International Shipbuilding Corporation had steamed 2,892,221 miles, carrying 2,920,588 tons of cargo. The *Quinstconck*, the first of the Hog Island fleet to be launched, had traveled more than 70,000 miles to the date mentioned.

AN ABSURD VENTILATION THEORY

"One of the most mischievous notions that ever found a place in the theories about school ventilation," writes Jacques W. Redway, F. R. G. S. of the Meteorlogical Laboratory at Mount Vernon, N. Y., in the *American School Board Journal*, "is now going the rounds. It assumes as a fact that the air of schoolrooms is thoroughly impure and vitiated; but declares that, if the air is kept in motion, all the badness is taken out of it. A more idiotic notion could not be conceived. A slight stirring of bad air certainly takes away a lot of the discomfort that it carries when still. Because it stimulates evaporation from the skin it is refreshing. But stirring bad air does not make it pure and wholesome; and why schoolmen who are quoted as educational authorities should hand out such senseless piffle is intelligible perhaps to themselves, but not to anyone else. Incidentally, no harm comes from keeping ordinarily pure air in motion."

LIQUID AIR CONTAINERS

Originally most of the German containers for liquid air were made by the firm of Burger, of Berlin, in silvered glass. Then Ahrendt succeeded in manufacturing very good vessels of two concentric spheres of brass or copper; the vacuum in the space between the two shells was not perfect, but was improved by placing charcoal in this space. Such vessels lost 0.029 kg. or 0.034 kg. of liquid air per square decimetre per day, against 0.023 kg. in the Burger vessels. Banneitz tried celluloid in sheet 3 mm. thick, but it was too brittle when cold. Nickel and copper have both been used (before the war) by Lilienfeld. The trouble with some metals is that they contain gases, and to get rid of these, the metals have to be heated to fairly high temperature. They are also easily heated by Foucault currents and they radiate heat. Iron has to be heated to at least 300 deg. C. for primary evacuation, and has to be silvered to avoid the radiation; this silvering cannot be done by a spray process, as the silver film is not sufficiently adherent and smooth, but has to be applied galvanically. They made also three-walled vessels, the intermediate iron wall, silvered on both sides, acting as a screen to prevent radiation, as suggested by O. Wiener, and in these vessels they brought the losses of liquid air down to 0.075 kg., whilst the loss was 0.6 kg. in two-walled, not silvered iron vessels.

One of the most daring ventures in deep mining ever conceived is that entered upon by Calumet & Hecla Mining Company and now nearing time when it will be put into actual use. It involves the construction of a haulage way a mile and a half in length at a depth of 3,100 feet, connecting all of Calumet & Hecla and Tamarack and Conglomerate Lode shafts from South Hecla branch to the Red Jacket shaft of Calumet & Hecla. This haulage way will be used for transportation of all conglomerate rock constituting the richest portion of the Calumet & Hecla and Tamarack properties, the rock to be hoisted through the Red Jacket shaft, one of the world's deepest holes.

A MACHINE FOR TESTING THE PNEUMATIC HAMMER

By ROLAND H. BRIGGS

British Editorial Correspondent.

IN AN AGE of efficiency, the practical results obtained from theoretical calculations must be measured and checked, for it will be often found that the intentions of the designer have not been fulfilled in the results achieved by the completed mechanism he has designed. Unforeseen circumstances which appear in practice are often overlooked during the initial inception of the machine, and their presence and effect are only realized after the machine has been put into actual operation.

A combination of theory, experiment, and practical experience, however, soon enables the designer to fix a definite point at which the best results of combined efficiency, economy and quality of work produced are obtained. During experiment it is necessary to ascertain at what speed the machine is running, when the maximum or best result was attained, and subsequently it is necessary to be able to check the speed of other machines to ensure they are up to the required standard.

With most machines this speed checking is a simple matter, depending only on the correct use of a speedometer and stop watch, or on the counting of the number of articles produced in a given time, but to measure the speed of the blows delivered by a pneumatic hammer is a very different matter. The rapidity with which these blows are delivered is so great that they cannot be followed by the eye, and the violence of the blow struck and the vibration caused make it impossible to use any ordinary counting mechanism to obtain a record of the speeds attained.

An interesting counting apparatus for this purpose is shown in the illustration. It has been produced by Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., of Newcastle-on-Tyne, England, and not only gives a permanent and continuous record of the strokes per minute of the hammer, and all variations of speed during the time that the hammer is under test, but also gives data with regard to the power which the hammer exerts. The power of the blows is measured on the crusher gage principle, and the speed with which the blows are struck is given by a tuning fork counter and a continuous diagram indicator.

Machine for testing pneumatic hammer.

The apparatus is built upon a rigid bedplate, which carries the steel cylinder for holding the test piece and the special snap, above which the pneumatic hammer is shown in position in the illustration. A spring motor drives a drum, round which is wound a coil of white paper. This paper is unwound by the drum and wound up again by the second drum shown, the train of gear wheels carrying the drive being clearly seen.

In the steel cylinder carrying the special snap there is a small lever which works on a hardened pin and is kept in position by check nuts, and one end of this lever rests on the collar of the snap and to the other end the silver wire pointer which indicates the blow is fixed. One end of a spiral spring is attached to the lever and the other end to the bedplate, this lever assisting reciprocation of the lever and at the same time damping out excessive vibration when the hammer is working.

At the further end of the bedplate a bracket is bolted, which has a single eye to contain the tuning fork. The latter is fitted with a silver wire to record the vibrations. This tuning fork vibrates at a constant speed of 50 vibrations per second. When the apparatus is set in motion the action of the recorder is as follows.

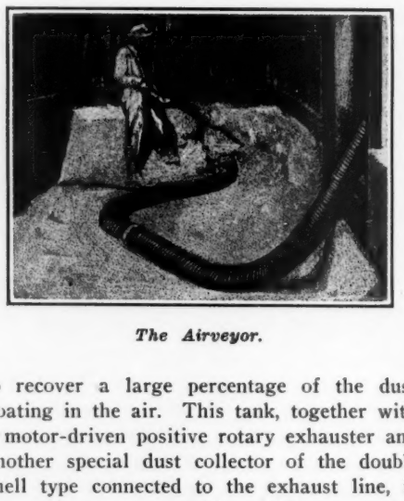
The spring motor is released and the hammer started. The blows of the hammer compress a metal alloy test piece, and the power of the blows given is calculated from the length and diameter of test piece of a known composition given in a stated time. The speed of the blows is obtained from an even simpler calculation. As the reel of paper unwinds, a mark is made at each stroke of the hammer by the pointer on the lever which is in contact with the snap. The pointer draws a series of short strokes on the unwinding paper, and at the same time the pointer on the tuning fork is drawing a wavy line on the paper, each wave representing a period of time of one-fiftieth of a second. It is therefore clear that the number of waves between two marks of the lever pointer, represents the time which has elapsed between the particular two blows of the hammer, so that a very accurate record is obtained of the number of strokes per minute given by the hammer, and of the regularity of those strokes.

The U. S. Bureau of Foreign and Domestic Commerce issues report on July exports and states that increased exports but slightly decreased imports in July as compared with June are disclosed by official trade figures; July exports were valued at $654,000,000 against $631,000,000 in June of this year.

THE "AIRVEYOR"

THIS IS a new word; not very satisfactory even as words go, but at least suggesting a special device for which no name has hitherto been provided. It quite evidently is to designate a device or arrangement for the conveying of material by means of air, but whether by pressure or vacuum the word gives no hints.

The word we understand originated with the Guarantee Construction Company of New York, and it is applied to a suction apparatus. A portable airveyor was installed by the above company at the plant of the Federal Plate Glass Company, Ottawa, Ill., to handle soda ash, salt cake and powdered lime from cars to bins. In handling such material the floating dust in the air is not only uncomfortable to work in but also injurious to the health, but with the "Airveyor" system this trouble is entirely disposed of. The fine, loose material is drawn from the car through a flexible hose into a vacuum tank designed



The Airveyor.

to recover a large percentage of the dust floating in the air. This tank, together with a motor-driven positive rotary exhauster and another special dust collector of the double shell type connected to the exhaust line, is mounted on a movable platform running above the storage bins and delivers the material through a rotary airlock feeder directly to storage. The dust recovered in both tanks is collected separately and also delivered through rotary feeders to the bins, so that there is very little dust shown at the exhaust.

The airveyor has been in successful operation for about six months, and enables the purchaser to unload material with one man in the car, working under much more agreeable conditions. The inside of car, as well as the storage house, is entirely free from the obnoxious dust, thus allowing other work to be done on the premises during unloading, which was impossible before.

The airveyor is handling material at the rate of ten tons per hour, and its capacity could have been greater if building conditions had not made it impossible to increase the size of apparatus. Airveyors can be built to handle quantities up to twenty tons per hour for movable units, while when stationary, a capacity of 40 tons can be obtained without making the installation too costly and cumbersome.

The Air Compressor in the Power Plant—II

By SNOWDON B. REDFIELD*
Engineer-in-charge, Engineering Department, Ingersoll-Rand Company, Easton, Pa.

ALTHOUGH the fact is not always appreciated, it is true that the building of a high-grade air compressor is just as much of an art as the building of a steam engine or turbine. In fact, the compressor builder has a far wider range of variables than the builder of engines and turbines; the latter has but a limited range of pressures, superheats and vacuums, and he usually aims to develop a certain limited range of mean effective pressures, while the compressor builder's pressures alone range from the highest vacuum pump to as high as 4,000 lb. per sq. in. Also, compressors are built not only for air, but for gases—natural gas, city gas, oxygen, acetylene, hydrogen, nitrous oxide, carbon dioxide, sulphur dioxide and ammonia —and there are many hundreds of compressors used for the purpose of "squeezing" out gasoline from the casinghead gas of oil wells.

Just as the builders of high-grade engines and turbines strive to turn out a machine that will do the most work for the least expenditure of steam, so the compressor builder aims to produce a machine that will compress the most air or gas for the least expenditure of power. When standard compressor units run into the thousands of horsepower each, it will be appreciated that economy is highly essential. Such considerations lead to various refinements of valve mechanism, single-stage, two-stage and three and four-stage compression, with highly efficient cooling devices in cylinder walls, and especially between stages of compression.

In cases of new installation the foundation and piping schemes must, of course, be planned ahead of time. The builders furnish plans that show foundation and pipe connections for steam, air and water, and it is always well to follow these as closely as possible because they are based upon thought and experience with this class of machinery. Of course the ground for the foundation must be firm, or else the foundation extra deep.

Different Types of Steam-Valve Gear

In the past, when rotative speeds were lower than they are today, the Corliss steam-valve gear was considered the best for highly economical steam-driven compressors. This type is so well-known and understood by power-plant engineers that it needs only to be mentioned here. In these machines the air-pressure governor changes the cutoff to control the speed and air quantity. The governor may control only the high-pressure side of a compound engine or it may control both cylinders. In the former case the steam-receiver pressure will change with the cutoff and so the proportion of load will vary between the two cylinders. In the latter case the steam-receiver pressure will remain constant and so will the division of load.

In an air compressor the mean effective pressure in the cylinders remains so nearly constant throughout a wide range of speeds that there is but slight difference of cutoff trom full speed to slow speed, so that the refinement of having the governor control the cutoff in both steam cylinders of a compound unit is not usually resorted to. The low-pressure cutoff is generally adjustable by hand to secure a proper average steam-receiver pressure and distribution of load.

It should be needless to say that with a Corliss steam gear the throttle should be wide open while running, to secure economy. Observation, however, reveals that too often this practice is not followed.

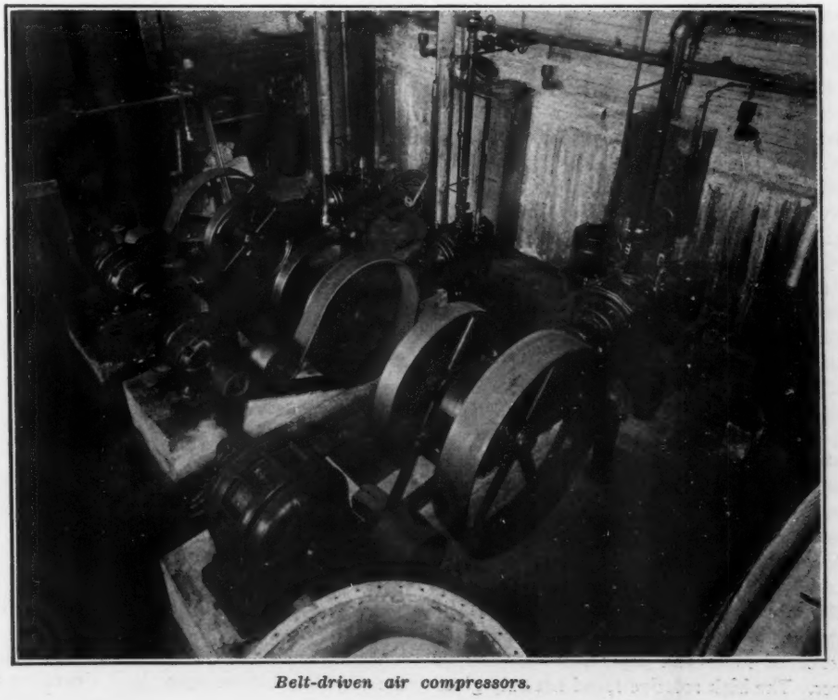
Another form of steam-valve gear which was quite universally popular fifteen years ago was the Meyer cutoff. As mentioned, the mean effective pressure is so nearly constant in an air compressor that this form of cutoff could be used to secure good economy, for when the valve was once properly set it needed little adjustment. The fact was, however, that it was so much easier to start a compressor with a long cutoff, few operators took the trouble to adjust the valve to short cutoff. The result was that the Meyer cutoff was more of a "selling point" than one of practical value.

Since the day of the Meyer valve there have been designed some compressors that really do obtain the high economy of the short cutoff. These machines use the well-known balanced piston valves, and some are single valves controlled by a flywheel governor, similar to the automatic cutoff, high-speed steam engine, while others employ the Meyer principle of a concentric cutoff valve within the hollow main piston valve. The cutoff valve is then under the direct control of the air governor and the obtaining of the high economy of the short cutoff does not depend upon the necessity of adjusting the rider valve by hand. The action is then just as automatic as a Corliss gear, with the added advantage of higher speeds and ability to use higher superheats.

With the former type a 75-hp unit running on 100 lb. steam pressure, non-condensing, may have a steam consumption one-fourth less than the ordinary throttle governor and fixed cutoff. With the more elaborate form having Meyer cutoff controlled automatically by the air pressure, steam economies equal to Corliss steam gear are attained and sometimes exceeded.

With any of these machines employing governor-controlled automatic cutoff, it is essential to economy that the compressor be run with throttle wide open. For electric-driven small compressors the belted unit is most usual. Gear drives are not so universally satisfactory for compressors, no doubt because of the uneven turning moment; as an improvement upon the disadvantages of gear drive some compressors are regularly built with a belt idler attachment. By this means the compressor and motor may be set almost as close together as if they were gear-connected and yet not have the troubles and noise of gearing. At the same time the idler enables much greater belt contact surface to be obtained and so makes it possible to cut down belt tension, with its attendant bearing friction and wear.

For larger electric-driven units the motor is usually mounted directly upon the com-



Belt-driven air compressors.

*Abstracted from "Power."

pressor shaft in the same manner as engine-generator units. With these machines it usually is customary to furnish a synchronous motor. Such a device may be adjusted by over-excitation so as to improve the power factor of the electric line, which is most desirable. By adding a good-sized synchronous motor of this type to an electric system, less generator capacity may be required than with any other type, and also a cheaper unit rate for current often is obtainable from power companies. In purchasing such a unit, it should be determined in advance whether or not it is to act as a "rotary condenser" of this sort, and the purchase should be made accordingly. This is a study for the electrical men of the plant. If, however, the machine is simply to run at "unity power factor," the exciter rheostat is adjusted until the compressor motor draws the least main-line current.

Starting the Motor

The synchronous motors furnished on these direct-connected units are of the self-starting type. The windings are so arranged that under light torque the motor will start as an induction motor and when at nearly full speed the throwing of the exciter switch puts it into "step" and the motor then operates in synchronism with the generators.

To start with light torque, some form of starting unloader must be provided. After having turned on the cooling water in preparing to start the compressor, it is important to see that this regulator is set in the light-load position before throwing the switch. If this is not done, either the circuit breaker will be thrown open or some injury may be done to the motor.

In the high-economy compressor the type of air valve used plays a most important part. A few years ago most air-compressing cylinders were provided with Corliss or, rather, rotary air valves moved by eccentrics, and usually the discharge valves were of the poppet type.

With valves of this kind the rotative speed of the compressor was limited, not only on account of the excessive noise of the poppet valves, but the valves being relatively heavy, the severe pounding they received made them specially liable to breakage. Also, the speed at which the rocking Corliss inlet valves could be operated was limited, as the inertia of the valve parts and the consequent strains on the parts became quite severe, especially when acute angles were employed in order to get quick opening movements. Since the best days of poppet and Corliss air valves there is a marked preference among practically all compressor builders to use some form of so-called "plate valve." These are of many kinds, being made out of thin plates of steel. Some are circular one-piece perforated plates, some are strips, and some are in the form of rings. All these valves are assembled to some form of seat which is put into the cylinder casting and held there by bolts.

The advantages of plate valves are principally the ability to run at high rotative speed, absence of noise and especially economy of power. The high rotative speed not only gives large capacity from a machine of a given size, but also means a much cheaper motor for a given horsepower when of the direct-connected, shaft-mounted kind. Absence of noise is of secondary importance, but is much appreciated by the operators in the power house, while the saving in driving power per cubic foot of actual air delivered, which is quite material, is a feature that appeals strongly to the man who is responsible for the coal or power bill.

In these plate valves the form of guide to the moving plate is an important matter affecting wear, and with it, tightness against leakage. To insure tightness, it is essential that the side play of the valve should be a minimum, so that it will always seat in the same place. The metal surfaces of the seat and of the valve then become exactly fitted to each other by the continued pounding in the same spot. To secure this condition the plate valves furnished by the Ingersoll-Rand Co. are guided, not by sliding on lugs or pins, but by the flexibility of the valve itself, part of the flexible arms being bolted directly to the seat. Thus the guiding and absence of side play cannot be affected by the wear of any sliding parts.

Valves of the plate type are also automatic in their action, being operated only by the air. Thus they are free from the possibility of wrong setting, which may occur with a mechanically moved or Corliss inlet valve.

This brings to mind an erroneous idea which was sometimes taken to indicate high volumetric efficiency. Every air cylinder must have some clearance or waste volume between the piston and cylinder head and under the valves, and at the beginning of the suction stroke this air must expand. If allowed to expand completely before the inlet valve is opened, it will do useful work upon the piston and assist in the driving. This may be shown by the re-expansion on curves of indicator diagrams. If, however, the inlet valves are made to open at the beginning of the suction stroke, this air trapped in the clearance space will simply "puff" out to atmosphere and the useful work that it might have performed is lost.

Effect of Premature Opening of Inlet Valves

The effect of this premature opening of the inlet valves will be to show a perpendicular drop in the line of the indicator diagram, and as this has been some times erroneously taken to show that the clearance is small and so the quantity of air trapped therein small also, it has been claimed that it showed high volumetric efficiency. As a matter of fact, the amount of air trapped in the clearance space, instead of being discharged, is exactly the same whether the clearance air is allowed to expand or not, so this premature opening of the inlet valves not only does not truly show more air handled, but it also is a direct waste of power in not giving up its useful energy by being allowed to expand behind and help the piston.

With plate valves automatically operated by the air, they cannot open until clearance expansion is completed, so that the energy of the air is usefully employed in assisting the piston during this part of the stroke.

In the care of air valves it is good practice to inspect and clean off the accumulated carbon at regular intervals. Carbon may cause leakage, and leakage certainly causes carbon. A leaking valve becomes hot from the passage of the heated air back through it, and this heat forms carbon from the lubricating oil. This carbon in turn may make worse leakage and worse heat, resulting in an overheated and warped valve, which becomes worse with continued use.

Valve trouble may be located in several ways. In a compound compressor, if any of the low-pressure valves are out of order, the intercooler pressure will be below normal because the low-pressure cylinder will not be furnishing enough air to keep the intercooler pressure up to what it should be. Trouble with valves in the high-pressure cylinder will be indicated by a rise in intercooler pressure above normal. This is because the high-pressure cylinder will not be taking the air away from the intercooler fast enough to prevent the abnormal building up of the pressure.

The foregoing statements as to the effect of the valves upon intercooler pressure apply equally well to inlet or discharge valves. Any particular defective valve may be located by its being hotter than the others. This is especially true of the intake valves.

Measurement of the Amount of Compressed Air

Mention should be made that at present it is possible to measure compressed air by means of a nozzle. The only difficulty is that during the measurement, if accurate figures are to be obtained, the air must be discharged to atmosphere.

In this measurement the compressor discharges at its rated pressure into the main air receiver. From here the air is bled through a globe valve into a second receiver, in which is a nozzle of such size that it will pass all the air from the compressor at a pressure not greatly exceeding atmospheric. This pressure may be obtained with a water or mercury column, and knowing the temperature of the flowing air and the barometer reading, the flow may be calculated. By using a nozzle with a well-rounded entrance, the friction and eddy losses are so slight that the actual flow is within one or two per cent. of the theoretical. This has been proved experimentally many times and has become a standard method of measuring air flow. Many engineers' handbooks give the formulas by which the air quantity may be calculated.

The old method of estimating the volumetric efficiency of a compressor by measuring the length of the intake line shown by the indicator diagram has now been discarded as inaccurate and deceiving. This method assumes that the air shown to be in the cylinder is at intake temperature and that there is neither piston nor valve leakage. With some types of machine the incoming air is

greatly heated before getting into the cylinder, and this reduces the actual amount of air delivered to the work in the same way as described under the subject of "intake duct." The loss from these sources may cause the actual delivery of the compressor to be from three to fifteen per cent. less than the so-called "indicator-card volumetric efficiency" would show. This loss is vitally connected with the design of the compressor and is therefore a most important point.

COMPRESSED AIR SAVES AMERICAN STEAMSHIP

By R. H. BRIGGS

An unusually difficult salvage job has been recently carried out by the raising of the U. S. S. *Rock Island Bridge*. This vessel has been raised and beached in a sheltered position from the deep water in which she lay near Falmouth, in spite of the bad weather of this last summer, during which the work has had to be carried out. The work has demanded exceptional skill, and reflects great credit on those concerned, and on the Ingersoll-Rand compressed air equipment with which the work was carried out.

The *Shipping World* in commenting on this venture says:—

"The *Rock Island Bridge* is a steel screw geared turbine steamer of 3,542 tons gross and 5,400 tons d. w. t., which was built at Newark, New Jersey, by the Submarine Boat Corporation this year to the order of the U. S. Shipping Board Emergency Fleet Corporation. On her maiden voyage, she was in collision off the Cornish coast, as the result of which she capsized and rolled over on her damaged side with all her decks and upper works fully exposed to the open sea. As a matter of fact, scarcely anything of her was to be seen at any state of the tide, as she lay in deep water off Porthallow, near Falmouth. In this condition by order of the owners, she was put up for public auction by Messrs. C. W. Kellock & Co., in London, on the 18th of May last, and was sold to the All Seas Marine and Salvage Company, Ltd., for £15,250, although the auctioneer at the time said she was worth, before she stranded, about £200,000. The relatively small sum paid for her was a measure of the possibilities of her salvage as entertained by buyers and experts.

"The All Seas Company was not daunted, however, and forthwith proceeded to salve her. It was a long and difficult job. To pass wire hawsers under her hull and raise her in the orthodox ways was not possible without cutting her masts and clearing all her top hamper away—a difficult job at any time, but rendered doubly so, as all these were under water even at low tide. The salvage plan adopted was, therefore, of a more unusual nature, but its success has fully justified the risks taken. Nos. 1 and 4 holds were closed down with hatches of nine inch timber, with rubber joints and cement: Nos. two and three holds amidships were damaged by the collision and could only be partially blown out by compressed air. When everything was ready, four Ingersoll-Rand air compressor pumps, each capable of about 400 cubic feet of free air per minute, emptied Nos. 1 and 4 holds, and the vessel bobbed up and floated on her side. Not a rivet sprung; not a porthole lost its covering. In this condition, with her masts and the greater part of her decks still below the surface of the water, she was towed into the Helford River and safely beached."

AIR LORE CONDENSED

Air is a peculiar substance which we have on all sides of us whether we want it or not—like creditors, says a writer in the *Black Rock Journal*, published by the Butte and Superior Mining Co. It extends fourteen miles above us, and so far has been entirely sufficient, although air shipping may necessitate its being extended. Air is the cheapest thing we have. Enough to last a lifetime is thrown in with every arrival in town. Air changes its temperature according to the seasons, although hot air can be generated during any season. There is also an air produced on instruments, vocal cords, cats, etc. This kind of air should be treated by itself. Wind is air with a determination to get somewhere else as quickly as possible. The wind idea originated in Chicago and is rapidly being taken up in other parts of the country. Instruments constructed for the purpose show that air moves much more briskly during a campaign year than during any other. Fresh air is air that has just been made and not yet sampled.

Another kind of air not mentioned in the above is compressed air. Compressed air, unlike any other kind of air, costs money, is ticklish to handle and has to be confined to certain prescribed areas, otherwise it is liable to go on a rampage and make a big mess cause your hair to stand upright and make little shivers shimmie up and down your spinal column, as everyone knows that was working the night shift at the Black Rock not so long ago. The hot air found around the Black Rock, although it assumes the proportions of a gale at times, and is liable to come from any of a hundred different directions on the slightest provocation, very seldom does damage.

A PRACTICAL RUST-PROOFING PROCESS INVENTED

RUST HAS always seemed to be such an inevitable accompaniment of iron whatever its shape or condition when exposed or neglected, and the hopelessness of the task of permanently preserving the metal in perfect condition has seemed so insurmountable that few have seriously attempted it. Unexpected success, however, seems to have been attained quite recently. The Andrews rust proofing process, with a home at the Andrews Rust Proofing Laboratories, 821 Book Building, Detroit, is said to be exhibiting most satisfactory results. The following description of the process employed is given out.

The pieces to be rust proofed are placed in a furnace which burns a mixture of gas and air. It is claimed that after the work has reached the uniform heat of the furnace, an atmosphere is created that forms an oxide which penetrates the most minute pores of the metal. The work is then removed from the furnace and immersed in a bath of oil, heated to a temperature of 100 deg. F. The oil carbonizes and, mixing with the oxide, forms a paste which sinks into the pores. At the same time, quenching in the oil contracts the pores and seals up the deposit therein. While the temperature of the furnace is not given, it is stated that it is not high enough to distort or in any way injure the work.

Among the claims made for the process are: That parts treated by it have a fine ebony finish and that they have withstood a test by being sprayed with salt water in a closed vessel for 83 hr. and remaining suspended over the salt solution for an additional 157 hr. without being rusted.

ALUMINUM DUST EXPLOSIONS

Alan Leighton, in *Technical Paper* 152 of the Bureau of Mines, presents interesting data regarding explosions of aluminum dust. This material, now extensively used in the manufacture of a metallic paint, burns quietly when a small heap of it is ignited, but if distributed through a confined air space combustion takes place with violence. One authority (Stockmeier) states that the powder is not ignited by friction, but mixed with potassium chlorate it is readily so ignited. Mixed with air, aluminum powder can be ignited by an electric spark, and it is thought that some explosions have been caused by sparks from electric fans. It has been noticed that when water is thrown in burning aluminum, large volumes of hydrogen are evolved. Leighton found that aluminum dust laid as a train on a soft wood board could be fired by short circuiting a current through it, and that when water was thrown on the burning mass a violent puff resulted. It was also found that the dust sprinkled in iron at a dull red heat (about 600° C.) melted and stuck to the iron, but did not burn. Evidently the igniting point of aluminum dust is above that of coal dust. Commercial aluminum dust usually has a thin coating of oil, stearin or some similar substance.

The dust is so light that it is easily blown about and usually the articles in the workroom are covered with it. All apparatus should be tightly enclosed. If fan-suction is employed to carry off the waste, some form of dust precipitator should be attached a short distance from the grinding machine to minimize the risk of explosion. Explosions of flour dust often begin at the ventilating fans and spread to the rooms in which the dust is being produced. At the factories at which explosions of alumnium dust occurred, the ventilating systems seemed to be designed to keep the air in rapid motion, hence helped to suspend the material. There was no device to collect the dust.

It is well known that aluminum enters into combination with many elements with great heat disengagement. The heat of formation of aluminum oxide is nearly four times that of carbon dioxide. The metal also has a high specific heat,

It is evident that the commercial manufacture of the dust involves serious risks, which should be met by scientific construction of the apparatus and proper ventilating systems. Suggestions along these lines are given in Leighton's paper.

Air in the Manufacture of Dynamite and Gelatin

By E. M. SYMMES and H. N. MARSH
Hercules Powder Company.

SINCE DYNAMITE was invented in 1866, it has proven one of man's most effective agents. It has solved engineering projects once believed to be insuperable, assisted materially in expanding a net work of improved roads over our entire country; in a large measure, made possible our great rail transportation system, deepened river channels, dug hundreds of miles of canals, and played a part of first importance in the reclamation of our land, and, above all, in the development of our mineral resources.

As is well known, the manufacture of dynamite and gelatin involves certain hazards, and every effort is made in the design and operation of the plant, to use equipment that will afford the maximum of safety with reasonable ease of operation. For these reasons, compressed air is used extensively in the various operations, as there is no danger of high temperatures from the pipe lines, as in the case of steam, and from sparks, as in the case of motors.

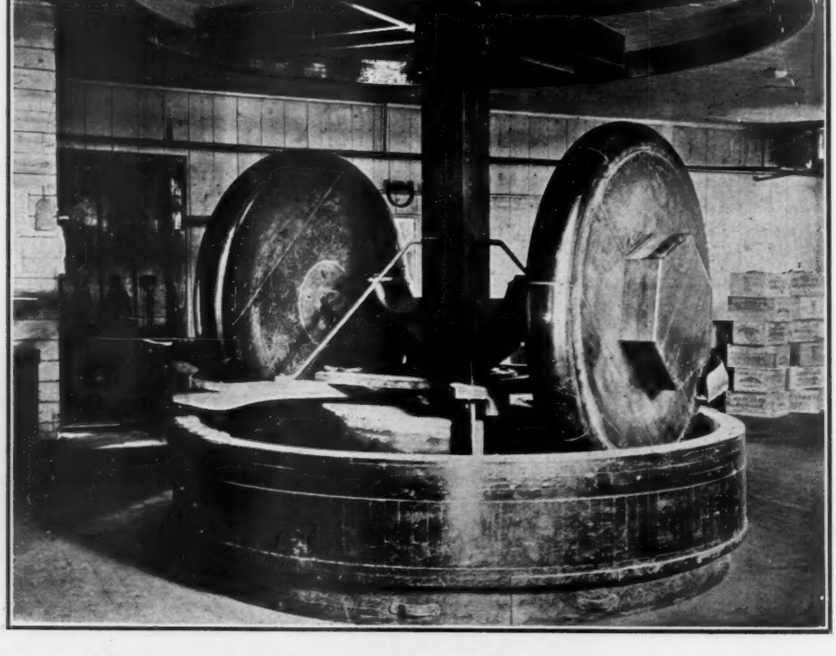
At the central power plant, a large air compressor and receiver is installed, and air is distributed in pipe lines to the various buildings which are separated over a large area for safety sake, and used in the various operations, as will be described later.

Dynamite is unique in not having been invented by the Chinese or mentioned by Shakespeare. It was first introduced by Nobel, the Swedish engineer, in 1866, after numerous accidents had resulted from the use of nitroglycerin alone. Mr. Nobel discovered that by mixing nitroglycerin with Kieselguhr, an absorbent earth, it became safe to handle, and its explosive power was not seriously reduced. Modern practice has eliminated Kieselguhr in spite of statements to the contrary in nearly every text book on the subject, and has substituted an absorbent composed of nitrate of soda, nitrate of ammonia, wood pulp, flour, etc., which gives an active dope, that is, one that will assist in the explosion instead of acting as an absorbent only, as is the case with Kieselguhr.

The method of manufacture and preparation of the various ingredients will be considered briefly before discussing the actual making of dynamite according to the process employed by the Hercules Powder Company.

Nitroglycerin is made by adding slowly to a mixture of strong nitric and sulphuric acids, a comparatively pure glycerin, agitating the mixture, meanwhile, by large mechanically driven paddles and removing the heat by coils through which cold brine is circulated.

As a safety measure, the nitrator is also equipped with a compressed air pipe running well down below the liquid level, which can be used to maintain a strong agitation of the acid mixture in case of failure or accident to the steam engine which drives the paddles. A modern nitrator produces about 3,000 pounds of nitroglycerin at one operation, consuming 7,000 pounds of mixed acids and about 1,200 pounds of glycerin. After all the glycerin has been slowly added to the nitrator, which is a steel tank with brine coils around its outer edge, the mixture is let down into a lead tank and allowed to stand until the nitroglycerin rises to the top and the acid falls to the bottom.



The nitroglycerin and dry dope are incorporated by a mixer. Heavy rubber tired wheels revolve in a wooden bowl, which contains the ingredients.

The top layer of nitroglycerin is then drawn off and delivered to a tank of warm water, where it is washed practically free from acid by vigorous agitation with compressed air. The nitroglycerin is then given a final wash by agitating it with soda ash solution to remove the last traces of acid and is then ready for use in the manufacture of dynamite.

The acid left from this operation always contains a small amount of nitroglycerin which makes it very hazardous to handle through pumps. For this reason, the acid is blown by compressed air from the nitroglycerin area to the acid area where it is treated in the acid recoveries to regain the nitric and sulphuric acids contained in it.

At the nitric recovery, a large amount of nitric gases are produced and these are converted into nitric acid by passing through absorption towers over which weak acid is sprayed. This weak acid is very corrosive, and is handled in pulsometers operated by compressed air.

In the manufacture of dynamite the absorbent material known as dope, is prepared by weighing out into a wooden hopper, the proper proportions of ground nitrate of soda, nitrate of ammonia, wood pulp, flour, starch, sulphur chalk, etc., which is elevated by an air hoist into a revolving screen and which discharges into fibre barrels. These are taken to the mixing house and emptied into a dynamite mixing machine, an illustration of which accompanies this article.

Nitroglycerin, after preparation and treatment, as outlined above, is taken by means of the copper lined, pneumatic-tired buggies (see illustration) to the mixing house, and is added to the dope. This mixing machine consists of a wooden bowl with large wooden wheels running in it. The wheels are surfaced with ebonite, or hard rubber, thus allowing no metal actually in contact with the dynamite while being mixed.

The driving of these machines is done with large overhead pulleys made of wood, which obviate any possibility of rubbing metal, thereby producing sparks. Five minutes kneading under the wheels of the mixer suffices in most cases, properly to incorporate the nitroglycerin throughout the mass of dope.

This material, which is now loose dynamite, is removed from the machine by wooden shovels, and put into wooden tubs, which are used to transport it to the Hall machines where it is packed into paraffined paper shells by the action of wooden tamps, tipped with rubber.

The shells are fed by air into a shuttle which is held in position by air cylinders and turned by air as soon as the shells are packed.

These shells are made by a machine which takes roll paper of from eighteen to 24 inches wide, cuts it into proper size and prints the

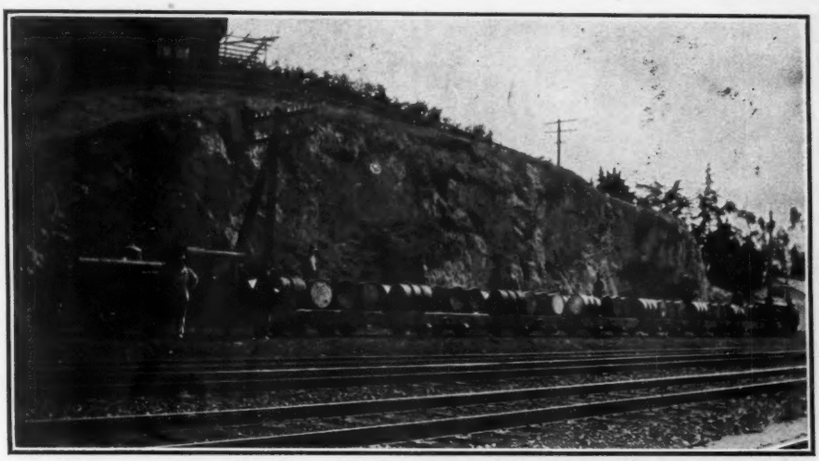
grade and strength of the powder to be packed. A mandrel then picks up this sheet of paper by vacuum and rolls it into a cartridge, crimps one end and the cartridge is then discharged by a jet of air into a carrier at the rate of from 180 to 200 per minute. They are packed loosely into crates and taken by traveling chain through a chamber where they are sprayed with hot paraffine to impregnate the paper and prevent absorption of the nitroglycerin. They are then delivered by tram truck to the Hall or to the gelatin packing machine.

These Hall machines are really marvels of mechanical ingenuity, and are almost automatic. It is only necessary to maintain a supply of loose powder and sufficient shells in order to perform the complete operation of filling the cartridges to the required amount, crimping the top, and laying them out on a table. They pack at each revolution either 25 or 30 cartridges, depending upon the size. This is a great improvement over the old days when each shell was filled through a funnel by hand operation, requiring every stick to be handled several times.

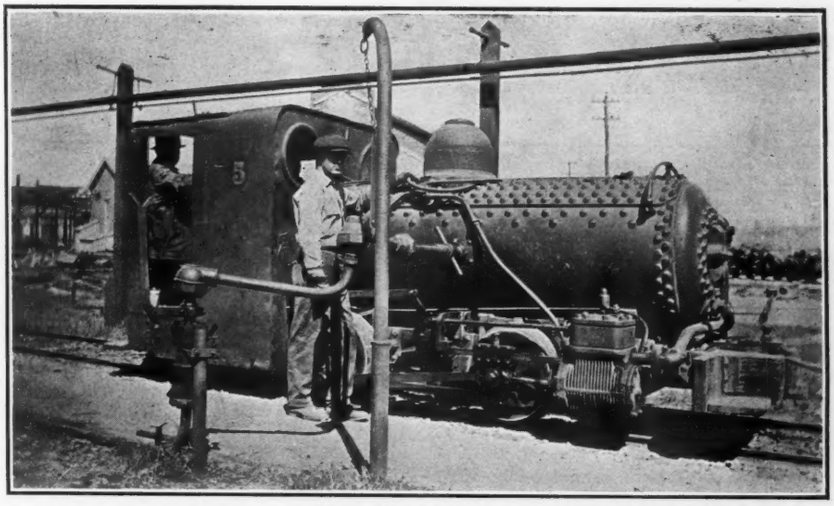
These cartridges of dynamite are then carried in wooden tubs to the packing house, shown in an accompanying illustration where they are sealed so that the dynamite cannot absorb moisture by being loaded into a wire basket attached to an air hoist, which lowers the basket for an instant in molten paraffine. They are then placed in paraffin-paper lined boxes, containing a small amount of sawdust for a cushion, are carefully weighed to be sure that they contain the marked amount and nailed up by an automatic nailing machine, which completely fastens the cover in two operations. From there, the boxes of powder are loaded on a truck and are hauled by a compressed air locomotive to the magazine, which is merely an unheated barricaded storehouse situated on a broad gage spur for convenience in shipping.

Since dynamite does not withstand the action of water very well, it was long ago discovered that the addition of small amounts of nitro cotton to the mixture of nitroglycerin with various absorbents, produced a material somewhat similar to jelly. This material resists the action of water exceedingly well, and is known as gelatin dynamite. Owing to its nature, gelatin is manufactured in different apparatus, and in a quite different manner from dynamite. The nitroglycerin and dopes, prepared as outlined above, are taken to a gelatin mixing machine shown in the illustration which consists of a bronze bowl surrounded by a lead jacket, containing warm water and fitted with two bronze paddles in a movable frame, which knead the dough-like mixture. These hold from 500 to 600 pounds of the gelatin for each charge and after the charge is introduced, the movable head carrying the paddles, is lowered by an air cylinder and the mixture kneaded until the correct consistency is obtained.

The head is then raised by the cylinder and the mixed gelatin which looks much like ordinary dough made from war flour, is shoveled out into wooden boxes with wooden

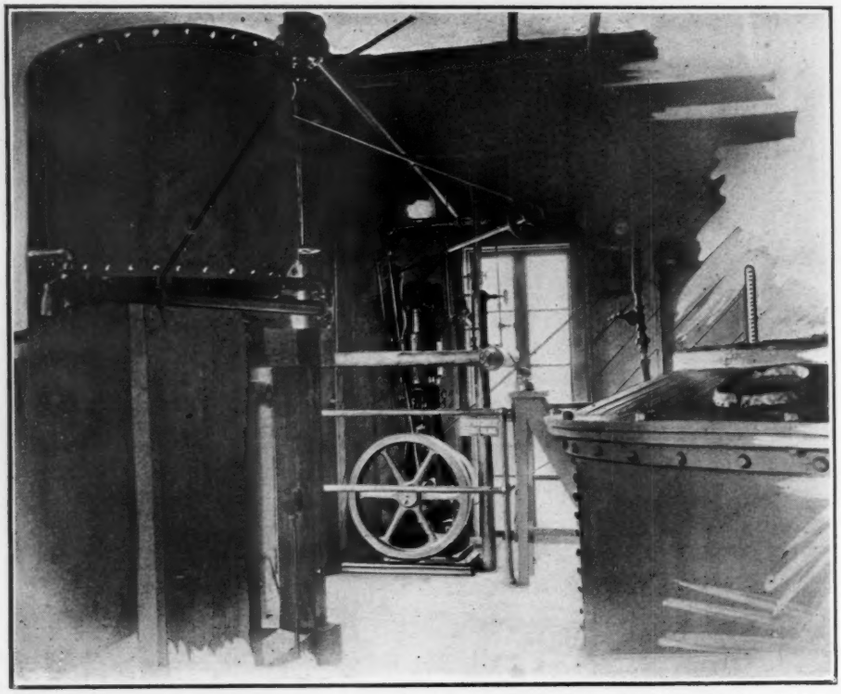


A compressed air locomotive hauling drums of glycerine to the nitro-glycerin plant.



A compressed air locomotive is used to transport the finished powder to the magazine.

Pneumatic tired buggies are used to convey the nitroglycerin from the storehouse to the mixer.



The nitrator tank on the right contains mixed acid into which glycerin is fed from the scale pot on the left, and the mixture is agitated by powder from the small engine in the center.

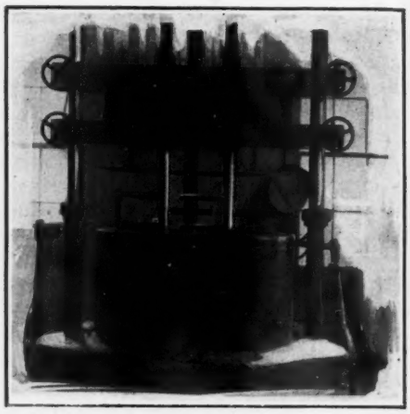
scoops and taken to a machine, which, by the action of a worm, forces this material through nipples into paraffin-paper shells. The shells are transferred by air from the shell crates to the shuttles which are raised to the filling position by an air cylinder, filled, lowered and in the next operation, crimped by an air operated device.

This is known as the gelatin machine or Schrader, and is necessary because such a sticky mixture as gelatin cannot be handled through the Hall machines mentioned above. The rest of the operation of gelatin manufacture, consisting of packing in boxes and storage in magazines, is exactly the same as in the case of dynamite.

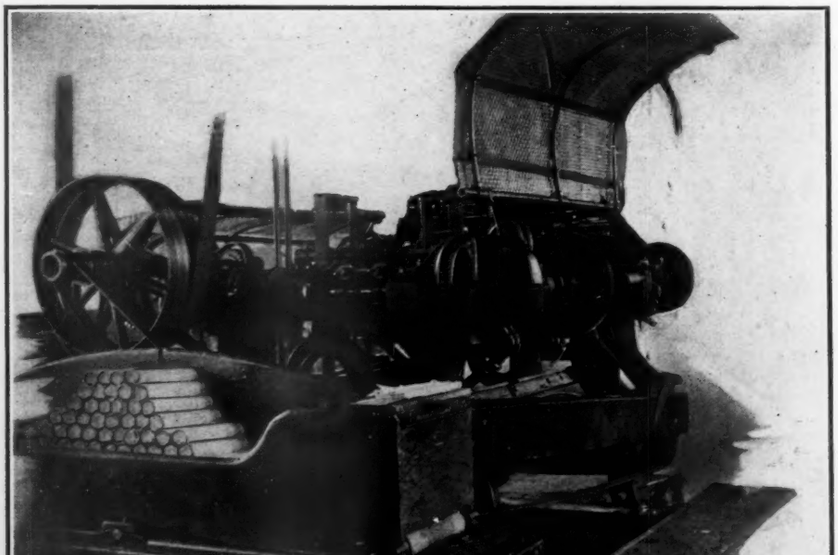
The manufacture of dynamite and gelatin may seem, from this description, to be a very simple process, but very close chemical control must be had at each stage to insure a high quality of finished product. Very careful supervision is exercised to keep the amount of moisture at a minimum on account of the serious effect water has on the ageing and strength of dynamite and gelatin.

The manufacture of nitroglycerin also receives very close supervision, not only on account of the danger involved, but also to maintain a high standard of quality. The fineness of the nitrate of ammonia and nitrate of soda used in the dope, is an important factor and receives the careful attention of the supervisors and control chemists. The pressure of the tamps in the Hall machines determines the density of the finished dynamite and also determines the number of sticks that a 50-lb. case will contain. Also slight variations in the composition of the dopes, have an even greater effect and must be watched.

It is believed that the above description of the various operations will make clear the great value of compressed air in the manufacture of dynamite and gelatin. Its use insures the safety of some otherwise hazardous operations and it is absolutely necessary to the handling of the weak nitric and spent mixed acids.



Nitroglycerin is incorporated with a special dope in a different type of mixer to make gelatin. Compressed air is used to lower or raise the paddles.



Paper cartridges are printed and rolled by a shell machine prior to being loaded with loose dynamite and gelatin.

BIG BUILDING PROGRAM FOR URUGUAY

The next few years will afford opportunities for the sale of many kinds of construction materials in Uruguay, according to a report issued by the Bureau of Foreign and Domestic Commerce, Department of Commerce. Uruguay is financially solid, its business is on a high plane, good workmanship is available, and there is a steady spirit of progress.

The biggest single project now being considered is a proposal for an international power plant to be erected on the Uruguay River by Argentina, Brazil and Uruguay jointly, with guarantees for the equitable distribution of power to the three countries concerned. On the site being considered it is calculated that 2,500,000,000 kilowatt hours per annum could be developed, or an energy equivalent to that of 3,000,000 tons of coal. The project contemplates the construction of two dams, one movable and one fixed, with canals to the power plant. It will utilize a fall of 77 feet. The installation would also open for navigation 419 miles of river which today is inaccessible, and would permit the inundation of adjoining zones which are suitable for agriculture.

The Economics of Price Movements

Do the Old Theories Hold, or Has the War Scrapped Them? Factors that Influence Prices—Improved Machinery a Tendency Toward Lower Levels.

By RICHARD HOADLEY TINGLEY

THERE IS always more or less difficulty encountered in managing a downward price movement. Once it has set in, hysteria sometimes takes the helm and carries it to an excess not warranted by conditions. The price deflation that has been in progress since last May is of a somewhat spotted character and it it not certain that all of the recent reductions can be maintained. "We are of the opinion" says the National City Bank of New York in its circular on *Economic Conditions,* "that there is too much employment in sight in this country, and too big a crop in the barns, for a prolonged period of depression."

There are many who recall that, last Spring while prices were mounting with no sign of abatement, Prof. Irving Fisher of Yale University made the oft-quoted statement:

"We are on a permanently higher price-level, and the sooner the business men of the country take this view and adapt themselves to it, the sooner will they save themselves and the Nation from the misfortune which will come if they persist in our present false hopes.

"Business men should find these facts. To talk reverently about 1913-1914 prices is to speak a dead language today. The buyers of the country, since the armistice, have made an unexampled attack upon prices through their waiting attitude, and yet price recessions have been insignificant. The reason is that we are on a new high price-level, which will be found a stubborn reality. Business men are going to find out the new price-facts and act accordingly."

There is no reason yet to believe that Professor Fisher was wrong, temporary evidence to the contrary notwithstanding. Nearly every recognized cause that has made for high price-levels in the past still exists. Let us then examine some of these causes, theoretical and otherwise, for they are little understood, and are the subject of much controversy. Let us see if the time-honored theories of price-movements are being violated and if price levels are to continue to decline in contradiction to their teachings, or whether they will assert themselves to the stabilization of prices at reasonably consistent levels.

There is not a business man or manufacturer in the land that is not interested in the outcome, and it is my aim to throw as much light as possible on the much clouded subject.

The "Quantitative Theory"

This theory teaches that prices rise and fall with the quantity of money in circulation. When commodity price-levels rise, it says, it is because the quantity of money paid for goods at that particular time has been increasing faster than the quantity of goods. When price-levels fall, it is because the quantity of goods is increasing faster than the quantity of money paid for them.

In other words, double the quantity-of-money, and "other things being equal," prices will be twice as high as before and money will have but half its former value. Cut the quantity-of-money in half and, "other things will have half of their former level, and the value of money will be doubled.

Under this theory a rise in prices may be attributed to an acceleration in the production of money, or a fall in prices to a retardation therein; or, rising prices may be the result of retardation in the production of goods, and falling prices to over-productions—cause and effect being somewhat clouded. If this theory stands for anything at all, then it is easy to conceive that, at one time or another, and under one condition or another, either factor may be the cause, the other being the effect.

This "quantity-of-money" theory finds popular expression in the bare statement that, the more money there is in circulation in a given country or community at a given time, the higher prices will mount—withdraw substantial portions of the money, and prices will decline.

Professor Fisher is a supporter of the "quantity-of-money" theory; so is Professor Taussig of Harvard and many other eminent economists as well as most of the banks. Before it can be intelligently discussed and understood, however, attention must be given to other factors that enter in, and to what is meant by "other things being equal" which phrase is quoted from Professor Taussig.

Contributing Causes

Following this theory the principal contributing causes that, singly or in combination make for high price levels are:—

1—The presence of gold and other money in abnormal quantities;

2—An inflated currency;

3—An inflated condition of credits; easy credits;

4—A demand for goods and services in excess of supply; under production;

The several and principal causes that, singly or in combination, make for lower prices are:

1—The absence of a large gold reserve.

2—A low currency issue in which the ratio of paper to gold is at a minimum.

3—Tight money, or a normal or sub-normal condition of credits.

4—A supply of goods and services in excess of the demand, or an over-production.

5—A depressed stagnant state of business; a condition making for the curtailment of expenses for luxuries and all necessary things.

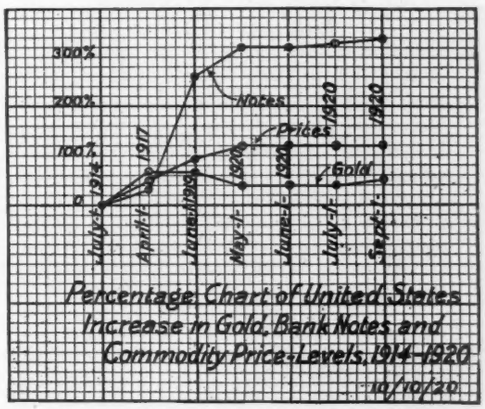
6—Improved methods of machinery, efficiency, and manufacture.

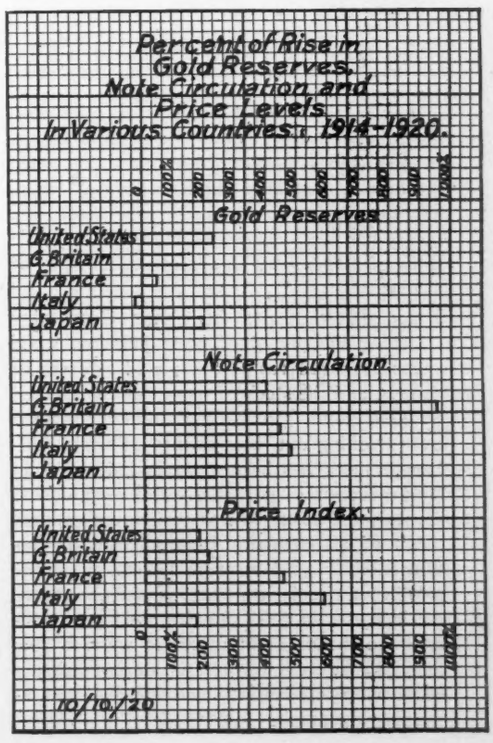
7—When the production of goods and services necessary for peaceful constructive pursuits overbalances, largely, the production of the destructive goods and services of war.

Let us examine some of these theoretically influencing causes and see how far they are borne out by the facts that experience has developed.

The Influence of Gold

On July 1, 1914, the total stock of gold money held in the United States amounted to $1,890,678,000. The enormous sums of the yellow metal sent to this country prior to our entry into the war in order to support the credit of Europe in the purchase of munitions and





other supplies, swelled this amount to $3,088,905,000 by the first of April, 1917. Embargoes upon the exportation of gold from this country served to retain this stock intact and even to increase it for it had reached the record figure of $3,092,038,000 by June 1, 1919, when the embargo was removed. Shipments of gold to South American countries and to Asia have since reduced this holding so that in September, 1920, the total stock stands at $2,688,744,000.

During this period commodity price-levels rose from index number, (Dun's), 120, on July 1, 1914, to index number 190 on April 1, 1917 (while the gold was coming in). By June 1, 1919, (while the gold stock remained practically stationary), prices had reached index number 228; still rising, (while the gold stock declined), to the peak of price inflation which occurred last May, (1920), at index number 263. September 1, 1920, finds prices have materially sagged off, to index number 248—and still sagging—while the stock of gold money has again increased from $2,646,616,000 on May 1, 1920, to $2,688,744,000, on September 1.

The Influence of Bank Notes

Following the course of the issue of bank notes; while price-levels were advancing to the peak (July 1, 1914, to May 1, 1920,) bank note issues also increased from $1,097,353,000 to $4,778,766,000. The following table and accompanying chart will illustrate this movement, both in figures and percentage.

INCREASES IN GOLD RESERVES, NOTE CIRCULATION AND PRICES
(In Millions of Dollars; 000,000 omitted)

	Gold Reserves		%	(a) Note Circulation		%	(c) Price Index	%
	1914	1919	Rise	1914	1920	Rise	1920	Rise
United States ..	612 (a)	2087 (a)	241	715	3523	393	272	172
Great Britain .	190 (b)	505 (b)	165	223	2333	946	305	205
France	804 (b)	1063 (b) (d)	32	1290	7102	443	550	450
Italy	231 (b)	210 (b)	*9	518	2964	472	659	559
Japan	110 (b)	325 (b)	196	163	567	248	272	172

(a) Bankers Trust Co. booklet "Financial Status of the Belligerents," pp. 22-26-27.
(b) National City, Bank Circular, December, 1918, p. 11.
(c) Federal Reserve Bulletin, August, 1920, p. 842 (1914 Index)—100 of the index number system of the U. S. Dept. of Agriculture.
(d) Includes gold held abroad.
*Indicates decline.

It will be noted that, while gold reserves in the United States increased 241 per cent, and note circulation 393 percent, commodity prices advanced 172 percent. During this period England's gold reserves were increased but 165 percent though her circulation sky-rocketed 946 percent while prices rose 205 percent.

In France, gold reserves increased 32 percent and note circulation, 443 percent, both less than either the United States or Great Britain, yet prices rose 450 percent—more than double the United States and Great Britain. In Italy we find an anomoly; gold reserves actually declined (nine percent) and note circulation increased 472 percent, yet commodity price-levels rose higher than in any country; 559 percent.

Nothing in the foregoing is seen that points to the infallibility of the quantitative theory of money and prices, but, as credit is but another form of money, let us see what it says:

COMPARISON OF INCREASES IN COMMODITY
PRICE AND STOCK OF MONEY IN THE UNITED STATES
(In Thousands of Dollars: 000 omitted)

	Dun's Index Number	% Rise	Stock of (a) Gold	% (a) Rise	Stock of (a) Bank Notes	% Rise
July 1, 1914	120	00	1,890,678	00	1,097,353	00
April 1, 1917	190	60	3,088,905	63	1,458,617	33
June 1, 1919	228	90	3,092,038	64	3,947,382	260
May 1, 1920	263	120	2,646,616	40	4,584,592	319
June 1, 1920	262	119	2,663,730	41	4,614,493	321
July 1, 1920	260	119	2,687,513	42	4,672,822	326
Sept. 1, 1920	248	107	2,688,744	42	4,778,766	336
Oct. 1, 1920	237	98				

(a) Including Federal Reserve note, Federal Reserve Bank notes, United States notes, and United States Bank notes. (Issue of August, 1920, page 825 of Federal Reserve Bulletin.)
NOTE: Tables compiled from Banking Reports contained in the Federal Reserve Bulletins.

It will be seen that prices acted quite consistently with the "quantity-of-money" theory so long as they were on the up-grade, but when the drop of last May began to develop, which has been going on steadily ever since, the theory has been violated as the increase in the stock of money goes on apace with no signs of abatement.

Price Movements in other Countries

During the period of price inflation, while prices advanced 120 percent; gold reserves 64 percent, and the stock of money as represented by bank notes, 319 percent, other countries were working out their own price-levels. Although there has been a marked decrease in the production of gold, the world over, during the war, and after-the-war period, the national banks of all countries have substantially increased their gold reserves by calling in the coin from circulation. Let us, then, compare the increases in gold reserves and note circulation in the different countries and see how they balance with the rise in prices with the assistance of the following table and the accompanying graph.

The Influence of Credits

A state of "easy" credits stimulates production. Until production has been increased thereby to a point where the quantity of goods produced has increased faster than the quantity of money (credits) paid for them, the effect will be to raise price-levels. On the other hand, when the influence of easy credits has so stimulated production to a point where the quantity of goods produced is greater than the quantity of money, (credits), paid for them, the effect will be to reduce prices. So long as bankers and others in control of credits have reason to believe that prices will continue to rise thus stimulating production and the possibility of large margins of profits, they will continue to create such credits in the form of loans to producers.

The creation and extension of these credits will greatly assist in bringing about the conditions which validate them. The continuation of the operation beyond certain well recognized safe limits is sure to bring about a condition which will cause their withdrawal. The real causes behind the initiation of rising prices which the theory says is a demand for a greater quantity of goods and services than the apparent quantity of money to be paid for them, will, eventually work themselves out and the inflation due to anticipation of a rise in prices will be checked. In the commercial world this operation is continually going on.

It is the demand for goods and services that acts first. This demand, so long as it exceeds the supply, makes for higher price-levels. Then credit steps in and the operation goes on till the influence thereof has produced a supply of goods and services beyond the demand. Then prices fall. Accentuated, these conditions become the "booms" and the "depressions" with which we are all familiar.

The Influence of Production

The basis of a nation's wealth is to be found in its natural resources and its manufactured products. Any influences affecting the supply of, the demand for, the cost of production, the manner and coördination thereof, the distribution and the cost thereof, are going to have a more potent influence on price levels than the presence or absence of the arbitrarily selected medium of exchange (gold), or the printing of paper money based on a more or less quantity of gold, or the extension of an easy credit, or otherwise.

All of these factors, although playing their part in the world's machinery of business, are of secondary consideration when compared with the basic things. We can do without gold, or currency, or credits, but we cannot live without the natural products of the soil and the articles manufactured therefrom. The basic influences, therefore, affecting price-levels of these indispensable commodities should be sought in the manipulation thereof.

Among these commodities may be found those which are classed as essentials and those conceded by some, though not by all, to be non-essentials. Among them, too, may be found articles of luxury, though, again, opinion is divided as to what constitutes luxury. An over-production of, and indulgence in luxuries (the term is used in its broadest sense) acts towards high price-levels since it takes capital (credit) and labor away from the production of essentials.

The Influences of Improved Machinery and Efficiency Methods

A wasteful process of production makes, too, for high prices. The formation of large combinations in given lines of business (trusts) have done much towards making for low price-levels through elimination of wastes.

It has been claimed that improved methods of production, of improved machinery, and in efficiency of production and manufacture are

strong influences making for low price-levels. At the close of the Civil War we were, practically, speaking, a nation of handworkers. Nearly all the great labor saving devices have been invented and placed in general use since that time. Great industrial development was going on, not only in the United States, but all over the world. Prices were falling. Was it as a result? From 1864 to 1897 price levels fell in the United States from 279 to 72 (Dun's Index numbers). Yet, from 1897 to 1917, (the latter year taken so as to disregard the influences of the war), prices again mounted from 72 to 119. Was there any less activity in the production and operation of labor saving devices? During this period the development of electric energy became complete, yet, all the economies brought about thereby, and by the intensive development of many important industries, could not keep prices from rising. Was it the increased cost of labor? Or, was it the influence of a currency issue that rose, during that period, from $16.75 per capita, to $34.35 per capita? Or, is gold really at the bottom of the price-movement phenomena? During this period the world's yearly gold production increased from $236,000,000 to $349,000,000.

The quantitative theory of money and prices originated with Ricardo a century or more ago, but at various times many economists have refused to accept it. Chief among its opponents is Professor J. Laurence Loughlin of the University of Michigan who devotes a large portion of his book, "Money and Prices" to proving its falsity. Prices, he argues, are determined by a great variety of factors, "of which the least may be gold or other form of money." "To many minds," he says, "the amount of a man's purchasing power is the quantity of money he can offer." "To my mind this is a superficial way of looking at the price making process." Rather, "that a man's purchasing power is measured, not by the amount of money he has . . . but by that part of his wealth which consists of cash or immediately salable goods."

Is the "Quantity-of-Money Theory" Still Operative

Most people would think that cash was money and that "immediately salable goods" were the equivalent of cash, wherefore a man's purchasing power after all had been measured in the amount of money he could spend. But there are many fine economic distinctions which people generally will not bother to understand. What Professor Loughlin proves and proves very well is that recently the effect of money upon prices has been over asserted, to the exclusion of other influences, of which the variety is endless. The pendulum swings too far. A few years ago this so called "quantity theory" was almost a heresy, because Bryan had preached it in terms of silver as a political doctrine.

I have thought it advisable to dwell at some length upon these too opposing price theories—particularly upon the quantitative theory, as this is more generally held—in order to bring out the fact that although at one time undoubtedly effective, it is not to be trusted implicitly on account of the topsy-turvey condition in which the war has left the world. Whether we believe in it, and the automatic effect of gold and other money on prices, or, following Professor Loughlin, that "price movements are determined by a great many factors, of which the least may be money"; whether we believe that huge volumes of gold and currency have been the cause, or, with the Federal Reserve Board, that it is but the effect; whether we believe in governmental intervention or not, a few facts stand out clearly that I will enumerate:

1. If the presence of an abnormal gold reserve has been responsible for inflated commodity prices in the past, then why, is deflation so rapidly in progress with no material reduction in the reserve?

2. If an inflated currency is responsible, why is deflation in commodity prices under way with no appreciable deflation in the circulation medium?

It seems apparent that the present deflation is more psychological than the result of the working of any material law as theory. The public has refused to buy because it considers the price of goods too high. Drastic cuts have therefore been made in prices. This proves one of two things, either dealers in essential commodities have been profiteering prodigiously, or they are now taking serious losses. If the latter, prices will again work back to higher figures as soon as the indignation of the public at what it considers an imposition, has spent itself. There are many advocates of this view and for the very good reason that labor, which represents from a half to two-thirds of the cost of every manufactured article, is still high and is not likely to come down proportionately. We have had a practical demonstration of this fact time and again—it is being emphasized every day.

The closest students of economic conditions are united in the belief that the present demand for deflation, though compelling, is but temporary. They do not look to see a return of the high levels of last May—but they do not expect a long continued decline—the profiteer is being "smoked-out" and prices cannot continue on the down grade indefinitely when every economic condition that has made for high levels, for the past three years (according to the accepted theory) is still with us.

A sentiment and certain amount of hysteria may knock the bottom out of prices temporarily; they may, and no doubt will, make for the establishment of a new and stable level—a level that, so long as labor maintains its present attitude, cannot be really low, a level that, unless the accepted and proven theory of generations is to be entirely violated, and unless the actual experiences of price movements is to be set at naught, cannot approach those of previous times.

Harry S. Wooden, transmission engineer and packing expert, has been made manager of the Philadelphia Belting Company with offices at 17 Battery Place, New York.

* * *

W. J. Baxter, first vice-president of the Republic Motor Truck Co., has resigned and is succeeded by Colonel Frank E. Smith, at one time connected with the Maxwell Motor Co.

Personal Intelligence

Mr. Marvin A. Neeland, President of the New York Shipbuilding Corporation, Camden, New Jersey, recently returned from a European trip, in the course of which he found several important business possibilities. Upon his arrival home he declared that the United States Shipping Board, if properly operated, still had the chance of being the most important factor in the maritime commerce of the world.

* * *

Alston Ellis, president of the Ohio University for the last twenty years, died suddenly at his home in this city from heart failure, aged 73 years old. Dr. Ellis graduated from Miami University in 1865. For several years after graduation from Miami University he taught school, and from 1868 to 1871, was superintendent of public schools in Hamilton, Ohio. He was also president of the State Agricultural College for several years, and had been president of the Ohio University since 1901.

* * *

Arthur E. Hauck, president of the Hauck Manufacturing Co., manufacturers of oil burning appliances, furnaces, etc., died at his home in Brooklyn, N. Y., recently. Mr. Hauck began his career by learning copper smithing in Germany. At the of twenty he came to this country and obtained employment in the Philadelphia Navy Yards, and in 1902 he started in the burner business and developed the business which now bears his name.

* * *

Arthur H. Waitt, a well known railroad engineer, died recently at his home in Sharon, Conn., after a few weeks illness. Mr. Waitt was born in Boston and attended the Massachusetts Institute of Technology. His first association with railroads was with the Boston & Maine, then with the Pullman Company, Lake Shore & Michigan Southern Railroad, and later became superintendent of Motive Power and Rolling Stock of the New York Central, with which road he remained 25 years, until his death.

* * *

John C. Pangborn, vice-president of the Pangborn Corporation, Hagerstown, Md., manufacturer of sand blast and allied equipment, sailed November 27 from New York, aboard the Olympic for Southampton. He will spend several months in Europe on business.

D. L. Thomson with Harvey Engineering Co.

Mr. D. L. Thomson, A. I. M. E., the well known sugar production engineer, and for many years with the Krajewski-Pesant Company of New York and Havana, joined the force of the Harvey Engineering Company, Ltd., of Glasgow, last Autumn. He is now at Lima, Peru, where he is making a study of projected reforms in sugar factories. An article by Mr. Thomson concerning the uses of compressed air in modern cane sugar houses is to appear in a forthcoming issue of COMPRESSED AIR MAGAZINE.

CONTROL APPARATUS AT THE WEBB MINE SCREENING PLANT

By A. TANCIG

Mechanical Superintendent, Shenango Furnace Co., Chisholm, Minn.

WHEN DESIGNING the Webb mine screening plant one of the main considerations was the elimination of as much hand labor as possible. Investigation showed that this could be accomplished if the plant could be handled by one man and all of the plant functions controlled from one central point. It was found that all of this could be done but that compressed air had to be used in the control apparatus as it had to be used anyway for starting and stopping the rock and ore trains

As the quantity of air that would be used was very small, not to exceed 35 cu. ft. we installed a 6x5-in. ER-1 Ingersoll-Rand Hopper cooled type of air compressor running at 400 RPM with short belt drive driven by a 10-HP, 220-volt AC motor running at 1170 RPM and equipped with magnetic control and automatic stop and start.

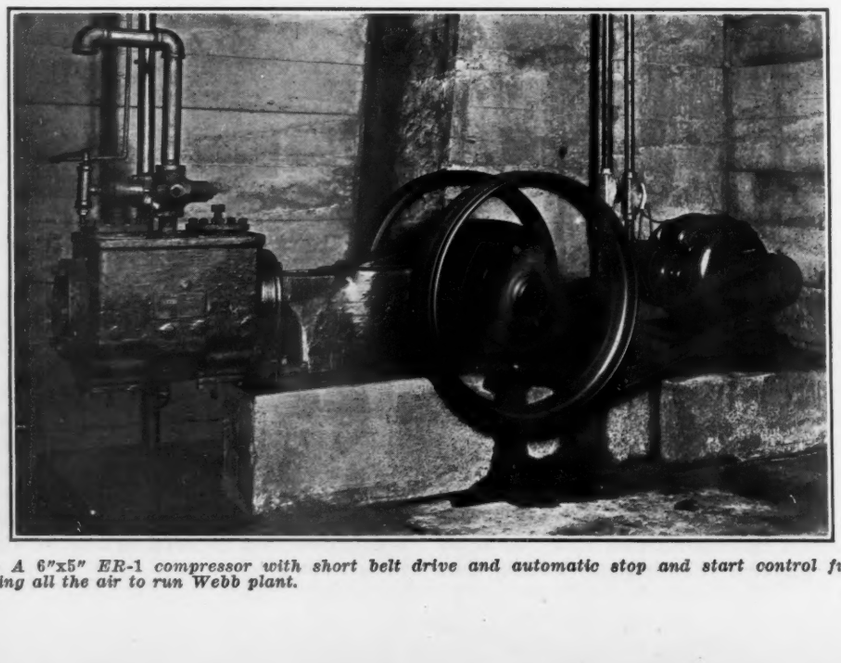
The apparatus controlled by compressed air is the rock chute, rock gate, ore bin gate, starting and stopping rock train and starting and stopping the ore train. The first three items are operated by 10-in. cylinders fitted with cup leather pistons. These cylinders are 10-in. in diameter by about 36-in. stroke. Pressure is admitted in the head end only and the piston rod is connected by wire rope to the gate or chute. As these gates had to be self-closing it was necessary to equip each cylinder with a quick opening release valve that would function automatically whenever the pressure was released. These valves are 2-in. in diameter and screwed into the head end of the cylinders.

The material that passes through the different chutes is necessarily loaded into either rock or ore cars and of course these cars must be moved or shifted as they become loaded. This is done by having the rock cars in one train and the ore cars in another and both trains running on parallel tracks having a grade of 2% in this case because the tracks are on a curve. Straight tracks would not need over 1.75% grade. Air is supplied to the trains by running a 100-ft. 1-in. air hose along side of each train and connecting it to the last car, the other end of the hose is connected to a supply pipe leading from the control valve on the operator's stand.

For the sake of simplicity it was decided to make the chute control valves the same as the train control valves so we installed five S-3, ¾-in. Westinghouse straight air valves, all mounted on a common header that received its supply from the main receiver. The air pressure used is the same as the pressure used for switch engine service, namely 90 lb.

The most gratifying feature about the plant is that labor has to a large extent been eliminated. One man starts, stops and controls the various plant functions from one central point and one man is located inside the plant whose duty it is to oil and watch the machinery. Of course there are other features that help to a large extent to make this a two man plant but compressed air is the most important.

The operator spotting and filling ore cars and rock cars controlling filling chutes with compressed air. Note hose connections to ore cars.



A 6"x5" ER-1 compressor with short belt drive and automatic stop and start control furnishing all the air to run Webb plant.

OXYGEN RELIEF IN GAS CASES

At a recent meeting of the Royal Society of Medicine, a discussion took place on the therapeutic uses of oxygen, in the course of which were given the results of the experience gained in the North Staffordshire Infirmary, where oxygen wards have been established at the instance of the Oxygen Research Committee, under the supervision of Drs. Shufflebotham and Sowry. The wards were opened in October, 1918, and more than 100 cases have been admitted. The cases included, for the most part, those of chronic gas poisoning, pneumonia, carbon monoxide poisoning, and two cases of pernicious anaemia. An extended report to be published by the Medical Research Committee would show, said Dr. Shufflebotham, that the results of the experiments carried out at the infirmary might be viewed most favourably. The patients suffering from chronic gas poisoning derived great benefit from a course of this treatment in the general state of their health, and, in many instances, symptoms of long standing, such as cough, shortness of breath, expectoration, asthma, and irregular action of the heart, became less severe in nature, and frequently disappeared. The physical conditions of the lungs and heart also underwent a considerable improvement. The men who had been unable to work on account of chronic gas poisoning and other conditions for a considerable period of time had not only so much improved in health that they could return to light labour, but, in many cases, they had been able to go back to their former employment. At present the cost is high. At Stoke-on-Trent it has not been possible to bring down the daily cost per patient to less than £1 3s. 6d., (say $6.00) and this estimate does not include any sum which could be put down to capital charges. The high cost of oxygen, said Dr. Shufflebotham, was due to the fact that the production of oxygen was in the hands of a monopoly.

Wind Tunnels Used by the Bureau of Standards

OUR ILLUSTRATIONS show several interesting devices by which Uncle Sam measures the various forces affecting aeroplane stability, the required horsepower for driving air planes, the wind resistance to projectiles in flight and numerous other factors depending upon atmospheric conditions.

Fig. 1 and 2 show the exhaust for motor and high speed wind tunnel for measuring the air resistance of a projectile. The eight-bladed fan requires about 100 H.P. to drive it at 1,200 revolutions which produces a wind speed of 180 miles per hour in the throat of the tunnel. The projectile is suspended from wires and is dragged down stream by the force of the wind. The observer looking into the tunnel is measuring the distance that the projectile has moved down stream, while the other observer is measuring the wind speed. From such measurements the resistance of a projectile may be computed.

Fig. 3 shows an ingenious method for testing the altitude resistance of aviators at the aerotechnique Institute of St. Cyr. in Paris. The device is a large tunnel about two meters in diameter. A powerful ventilator furnishes air currents and the various altitudinal conditions are accurately duplicated. The aviator is locked in this caisson, while a gage registers the "pressure-velocity, etc.", just as actually as in flight. The scale is known as "Aerody Hanique." In the "pneumatic caisson" an outside eye is kept so that the aviator inside does not meet with any harm, or does not suffer too much. By testing in this tunnel, the dangers met with at high altitudes are eliminated, for the flier who successfully passes the "test" can safely venture into highest altitudes.

Fig. 4 is an aerodynamical balance used by the Bureau of Standards for Measuring the wind forces on airplane models. The head resistance of the drag of the wind on the model is measured on one beam, while the lift of the wind on the model is measured at the same time on the other beam, at right angles to the first. The vertical arm of the balance projects through the floor of the tunnel and carries the model. By placing the model in different positions it is possible to make measurements from which the stability of the aeroplane may be predicted.

AN AIR COMPRESSOR LOST AND FOUND

Loss of an air compressor, weighing more than a ton, was reported to the sheriff's office in Salt Lake City recently, with the result that it was located in Stockton, Tooele County. The equipment, belonging to the Utah Granite & Marble Company, was taken from a location above Wasatch, in Litte Cottonwood Canyon, and transported to Stockton by team and wagon. The sheriff's office is still investigating.

Wireless telegraph instruments used at Woolwich are reported to transmit more than 2,000 words a minute. A range of 250 miles with an accuracy of one degree of use is claimed for a new miniature direction finder.

Compressed Air Magazine

—Founded 1896—

Devoted to the mechanical arts in general, especially to all useful applications of compressed air and to everything pneumatic.

Business and Editorial Offices:
Bowling Green Building, No. 11, Broadway,
New York City, U. S. A.
Telephone: Bowling Green, 8430

Publication Office: Somerville, New Jersey.

Chicago Office:
Peoples Gas Building,
Michigan Avenue and Adams Street
Sears & Irving,
General Western Advertising Representatives.

Business Office for the British Isles:
Advertisements and Subscriptions.
J. F. Atkinson, Representative.
No. 31, Essex Street, Strand, London, W. C. 2.
Telephone, Gerrard, 6659.

Cable Address:
"Compaire", New York. Western Union Code.

TERMS OF SUBSCRIPTION

$3 a year, U. S. A., American possessions and Mexico; all other countries, $3.50 a year, postage prepaid. Single copies, 25 cents. Back issues more than six months old, 50 cents each.

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Correspondence invited from engineers, chemists, experimenters, inventors, contractors and all others interested in the applications, practice and development of compressed air. Correspondents and contributors will please submit questions, or matter for publication, accompanied by self-addressed stamped envelope; they also will please preserve copies of drawings or manuscripts as we cannot guarantee to return unavailable contributions in the event of rejection, though our practice is to exercise diligence in doing so.

EDITORIALS

OUR QUARTO CENTENARY AS TECHNICAL JOURNAL

WITH THIS issue of COMPRESSED AIR MAGAZINE we celebrate the twenty-fifth anniversary of our existence in the international technical journal field, but with a scope that remains unique, inasmuch as there is no other periodical in the world devoted to the subject of compressed air, and its manifold applications. The publishers of this rapidly expanding journal—expanding both as to its service and its influence—are possessed of a comforting conviction that the magazine has more than justified its foundation and its continuous existence through the last 25 years. It has constantly grown and improved until now it has a staff of recognized experts writing for it in nearly all of the great engineering centres of the world. In the last year its European organization has been extended until it comprehensively covers the pertinent engineering field of the Continent and the United Kingdom. In the near future it is expected that a competent engineering correspondent will be added to the editorial correspondence personnel in Australia, to cover the Antipodes, and further editorial acquisitions will be a correspondent in South America, and one in the Far East. Our readers will thus be served with the results of the best engineering thought on the subject of compressed air and allied topics, throughout the entire world, and we are able to congratulate them, and ourselves, on this fact.

Old readers of the magazine will remember the modest garb in which it made it first bow in the technical press field. Its founder, WILLIAM LAWRENCE SAUNDERS, who was also its first editor-in-chief, and who has exercised a discerning editorial influence upon its columns ever since, still remains its head, as President of the publishing company. The editorial masthead of the first issue bore also the names of A. E. KENNEY, as Managing Editor, and those of A. NEWTON and J. E. QUINTERO as associates. A number of changes have taken place in the editorial staff since, but in the last decade or more, the veteran authority and writer on the subject of compressed air, Mr. FRANK RICHARDS, whose books and other treatises in infinite variety, on the subject of compressed air and mechanics in general, are known throughout the world of engineering, has had a guiding hand at the editorial helm. The magazine owes a great debt of gratitude to Mr. RICHARDS for the long years of service through which he carried it forward and upward until it reached its present high plane of widened activity, with one of the largest circulations among the monthly technical journals of the world. Despite his advanced age and his long and honorable service in the field of mechanics, first as an English apprentice, next as workman, then as a foreman, and for thirty years as a contributor and editor of the technical press, Mr. RICHARDS, still remains diligently at his desk, refusing to retire from work that is his life interest. This year of 1921, will mark his seventieth year in the field of mechanics, since he entered his first machine shop when he was thirteen. There are few living men, we believe, who can look back upon such a rich and varied experience, and it is the pleasure of COMPRESSED AIR MAGAZINE to pay tribute to his invaluable services and his fidelity to the best interests of the journal.

This publication frequently embodies in its text and editorial columns discussions of topics which make it more than merely a digest of compressed air and editorial practice, but which give it a flavor of general engineering and industrial information pertaining to nearly all the mechanical arts and processes. The magazine also keeps in close touch with the current literature of mechanics and engineering in general, while watching matters of everyday moment affecting the welfare of both worker and executive. This policy has so broadened the interest in the magazine that it has become one of the most frequently quoted technical publications of the world, as our records of cuttings from weekly and even daily publications attest.

The Editors desire to thank devoted readers and advertisers for their coöperation, and many of both have remained keenly interested and loyal through our quarter century of existence.

STATEMENT BY THE FOUNDER

IT IS PLEASANT to look back to a time just 25 years ago and recall the inspiration that prompted a few of us to launch a little monthly paper called COMPRESSED AIR. It was indeed an inspiration, for those of us who were intimately associated with the development of compressed air appliances really fell in love with the art. So little was known about it, so much seemed undiscovered; and yet it appeared that there were great possibilities in its path. Surely compressed air was important enough and big enough to have a sponsor, an organ devoted to disseminating information about its production, transmission and use.

And so a little paper was started, published monthly and sent to subscribers at one dollar a year. Its circulation for many years was small, but it went to all parts of the world, and always to those who were specially interested in the subject. The list was a concentrated one. To-day it is larger and less concentrated, because compressed air is not now a specialty, occupying, as formerly, a field all by itself. It now enters into all industry. It has become one of the important cogs in the wheels of general engineering practice. Always independent, never a house organ, this magazine takes a unique position in the field of industry. It is a means of education, a clearing house of information and publicity, not for any particular machine but for the development of the science as a whole. In doing this it should, and does, benefit all those who are interested in compressed air appliances —engineers, manufacturers and users.

W. L. SAUNDERS.

The publishers and editors of COMPRESSED AIR MAGAZINE wish the readers of the journal throughout the world a Happy and Prosperous New Year.

MULTIPLE PRODUCTION, NEW INDUSTRIAL KEYNOTE

QUANTITY PRODUCTION has been the battle cry of American industry for years, thanks to the machine tools devised and developed by native genius. But from now on we must adopt a new slogan, Multiple Production. The two phrases mean radically different things.

Up to the outbreak of the World War, we were able to hold our own rather well against the competition of cheaper labor abroad mainly because we used machine tools far more widely than they did across the seas. The compelling urge of strife, however, altered the situation. All of the belligerents were forced to turn out rapidly enormous quantities of identical products for service on or in connection with the battle fronts. They could not have met these demands had they not fallen back upon machine tools, a great many of which were manufactured here.

As an outcome of necessity, those hard-pressed countries had it brought right home to them wherein we had previously enjoyed an advantage, and one and all of them learned their lesson well. Henceforth they are going to utilize their cheaper labor in combination with machine tools to compete with us in the markets of the world. The American manufacturer and the American worker desire a satisfying compensation, and this they cannot have in the days to come unless other measures are adopted which shall place us more nearly upon a basis of equality with the alien in the realm of production. Our success in the future will hinge to a great extent upon the completeness with which every pound of raw material is made to bring in a return.

Multiple production means in so many words the fullest utilization of the primary materials supplied us by nature; and this is possible only by marketing the divers by-products. It was just this that Germany did when she built up her immense dyestuff industry; and the same chemical cunning and a kindred acuteness in other manufacturing activities enabled her prior to 1914 to undersell rival nations in disposing of many of her staple commodities. Germany will inevitably bolster up her foreign trade by an intensification of her practice of multiple production, for she knows that she must make each mark's worth of raw material yield a maximum revenue. Four years of desperate pinching, and science applied as never before to adaptation and substitution, have made her especially wise in what might be termed industrial conservation. The United States will have to meet this astuteness by recourse to the same expedients.

What Germany has done, England, France, Belgium, Italy, etc., will undoubtedly do, though all those countries have been far less spendthrift than America hitherto in the way they used their raw stuffs. Therefore, both quantity production and multiple production will play their respective parts in bringing about the economic rehabilitation of those war-stressed nations. In a sense, they will make common cause against us. Now let us see wherein America can mend its ways.

Out of every 1,000 feet of timber removed from our forests only 320 feet ultimately becomes available in the form of lumber. We waste annually in our sawmills about 4,000,000,000 cubic feet of wood. It is slowly coming home to us that mill waste is susceptible of many uses. Material that is more often than otherwise burned can be turned into laths; shade rollers; chair stock; brush, broom, and tool handles; boot and shoe findings; woodenware; matches; boxes and crates; toys; toothpicks, etc., not to mention paper and artificial silk. And then, in the realm of chemistry, wood waste can yield immense quantities of rosin, turpentine, ethyl, alchohol, tannin, etc.

Besides squandering money and dissipating energy in hauling coal needlessly long distances, instead of converting the fuel into electric power right at the mine mouth, we are scattering values broadcast with well-nigh every shovelful of bituminous coal that we consume. We cuss at soft coal because of its smokiness, quite forgetting that the grimy cloud is a warning signal of wastefulness. The same coal coked in a by-product oven will furnish several times its market price in salable commodities. That is, the coke, the gas, the ammonium sulphate, the benzol, and the tar recoverable from a ton of coal fetching three dollars at the mine—let us say—should bring in something like twenty dollars; and the coke, remaining after the extraction of the volatiles, be it remembered, is a superior smokeless combustible.

Again, as an example of how we neglect the bunghole while we boast of watching the spigot, just think of our high-handed treatment of the domestic supplies of petroleum. Until very recently we have tapped our oil sands with little heed to the day of accounting that our greed or shortsightedness was speeding nearer. Like bituminous coal, petroleum is rich in derivatives which can be recovered, and these worth-while by-products are sacrificed whenever crude oil is used as a fuel. Some idea of what this wastefulness amounts to now can be gathered from the fact that fully half of the crude oil taken from the domestic wells is burned yearly in the form of liquid fuel in steam plants, etc.

As most of us know, the demand for fuel oil is steadily increasing. Science has shown how we can have a superior liquid fuel and yet use in large part refinery wastes in its making. From crude oil, by successive refining processes, we get gasoline, kerosene, lubricating oils, benzine, fuel oil, vaseline, paraffin, asphalt, petroleum coke, dyes, and scores of other useful substances. Even so, to-day, five per cent of the crude oil handled by the refineries is reckoned as waste. What this means can be appreciated if we keep in mind that we are consuming annually close to 500,000,000 barrels of petroleum.

While still on this subject of petroleum, it should be plain that there is much yet to be done in the matter of improving the methods and facilities employed to draw oil from the subterranean sources. It is authoritatively said: "Under present practice from 90 to 30 per cent of the oil is left underground. Then, of the quantity produced, an appreciable percentage is lost by fire, a significant portion is dissipated by seepage and evaporation due to inadequate storage facilities. On the average, therefore, it is safe to say that less than 25% of the petroleum underground reaches the pipe line. If we subtract from this proportion the losses involved in improper and wasteful methods of utilization, the recovery factor becomes, perhaps, as low as ten per cent."

Industrial research is going to lead us into the right paths; and in the laboratory, ways will be devised by which we may stop leaks; make use of by-products; and generally achieve much through multiple production. Economy and efficiency must rule so that all of us may enjoy that plenty which we deem ours of right.

OUR NEW CORRESPONDENTS COVERING EUROPE

FIVE NEW correspondents for COMPRESSED AIR MAGAZINE have been appointed in European countries to represent its editorial interests and to keep its readers informed of events abroad within the scope of the journal. The editors are pleased to announce that at Paris, Mr. BEN K. RALEIGH and Mr. J. GASTON DELPUECH will act in their behalf. Mr. RALEIGH, a well known American resident of Paris, and a member of the American Club there, has for many years been a contributor to American trade publications, and latterly, during a two-year sojourn in London, he has written for English periodicals. Over a period of a decade he was an editor of the Philadelphia *Public Ledger*. At the outset of America's participation in the Great War, he served under former President TAFT on the War Labor Board, devoting most of his attention to the settlement of labor difficulties in the machinery and engineering trades.

Mr. RALEIGH is the General European Manager of the WHALEY-EATON service of Washington, which provides thousands of American and European industrial and financial executives with confidential information affecting their interests, and as such he keeps in constant and close touch with the economic, industrial, commercial, financial and political developments and phenomena of all Europe. He enjoys particularly intimate sources of information.

Assisting Mr. RALEIGH is M. DELPUECH, a writer and French publicity expert of engineering knowledge and familiarity with the most modern compressed air equipment. M. DELPUECH is connected with a large pneumatic engineering and machinery house at Paris and in this position is a close observer of compressed air practice in France and Belgium. These two correspondents at the French capital will prove a welcome and valuable addition to the staff of COMPRESSED AIR MAGAZINE.

Mr. CHARLES A. BRATTER is our new correspondent at Berlin, where he holds an important post as Foreign Editor of Germany's greatest and most conservative daily, the *Vossische Zeitung*, (established in 1704) which is quoted throughout the world. Mr. BRATTER lived for nearly 20 years in the United States, doing journalistic work and studying men and conditions. After a two years' stay in the Balkans, he settled in Berlin, where he has been connected the last twelve years with the larg-

est German publishing firm, Messrs. ULLSTEIN & Co., who are publishing five dailies, a variety of weeklies, and such trade and technical journals as *Die Holzwelt* (The Timber World), *Die Blauwelt* (The Architectural World) and *Verkehrstechnik* (The Technics of Traffic.) The *Vossische Zeitung,* like the London *Times,* publishes a special weekly supplement devoted to all branches of engineering. Mr. BRATTER is in a particularly advantageous position in Germany to provide for our columns correspondence concerning compressed air engineering and economical and industrial subjects, and he wields a highly intelligent and well-informed pen. His new editorial post will be important, since the eyes of the entire world will be upon Germany in her efforts to rehabilitate herself following the war into which she was thrust by her military authorities. At our request, Mr. BRATTER's first article concerns itself with the general economic situation in Germany and an analysis of the conditions as they exist today. Another early article from Mr. BRATTER will describe the uses of compressed air at the great KRUPP works in Essen. It is interesting to note, in passing, that Mr. BRATTER is the author of several books on America, among others, *Amerika von Washington bis Wilson* ("America from Washington to Wilson") and *Staatenbildung in der Nordamerikanischen Union* ("State Building in the North American Union.") His daughter, who was born in New York, is a Berlin correspondent for one of Chicago's most influential newspapers.

Mr. HERMANN BRINKMANN is our new correspondent for Austria and the surrounding countries of East and South Central Europe. He is a native of Germany, where he studied and took his B. A. degree in political economy. As a young man he left Germany for England where he lived for ten years pursuing commercial and literary work, his name often being quoted in connection with the anti-vivisection movement. Love of the tropics induced him to spend three years in various parts of South Africa, whence he returned to Europe in order to accept a post as manager for an English oil company in Galicia. This place he left to become manager for the British Humboldt Engineering Works, which he resigned at the beginning of the Great War. Mr. BRINKMANN had his own opinions about the war, its inspiration and conduct, and voiced them when he returned to Central Europe. It chanced that his views varied from those held by the German Government and he was imprisoned for a considerable period, eventually being released upon his engagement to keep his views stifled at least within himself. He is at present attached to the Vienna office of a machinery house. To Americans his name may not be unfamiliar, since his uncle was a famous physician of Philadelphia.

Our recently named correspondent at Madrid, who will cover pneumatic engineering and industrial topics for us in Spain and Portugal, is Sr. LUIS BALDASANO y LOPEZ, an engineer and writer who is connected with an American machinery firm. Mr. BALDASANO took a course in mining engineering at King's College, London, where he was graduated. For some time Mr. BALDASANO was a special representative in Mexico, Central and South America for Messrs. BIRCH & Co., of London, a mining machinery house. One of his most important accomplishments for his firm was a pioneer task of its kind, the complete compilation of a monster catalogue of 650 pages in Spanish, with all of its intricate engineering and mining terms. Mr. BALDASANO's early education was obtained in New York, where his father, the late Don ARTURO BALDASANO y TOPETE, was Spanish Consul General for nine years. Mr. BALDASANO for several years past has been the correspondent in Spain for the *Statesman's Year Book* of London.

WILLIAM T. PRICE

IT IS WITH deep regret that COMPRESSED AIR MAGAZINE informs its readers of the death of Mr. WILLIAM T. PRICE, Chief Engineer of the Oil Engine Department, Ingersoll-Rand Company, at his home in Easton, Pa., on Sunday night, November 7, 1920.

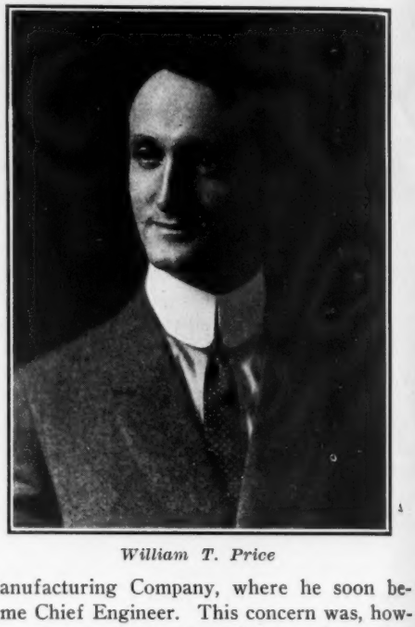
Mr. PRICE is best known by his conception and development of the Price system of handling fuel oil. Its principal features are a combination of low compression with Diesel economy and the elimination of hot bulbs and other artificial means of obtaining combustion. The result was an engine of high thermal efficiency and high mechanical efficiency. This was the goal for which engine designers had been striving since Doctor DIESEL took out his first patents and to Mr. PRICE belongs the honor of first having achieved this end. It is hard to imagine what he might have accomplished had he been permitted to finish out the three score years and ten allotted to man, instead of being allowed 37 years of life.

Besides his mechanical ability, Mr. PRICE possessed unusually keen business foresight. He was the exceptional inventor with sufficient business acumen to reap the benefits of his labor.

It was also Mr. PRICE's good fortune to be blessed to a high degree with the faculty of making friends. This was partially due to his youth and enthusiasm and partially to his consideration for the feelings of those with whom he came in contact. The humblest shop apprentice or cub salesman was accorded the same courteous treatment as the highest company official. It is little wonder that his acquaintanceship alone limited his circle of friends.

Mr. PRICE was born at Montreal, Canada, September 28, 1883. He attended Toronto Technical School. Before completing the course, he decided that he had had enough school and went to work. His inventive genius first exhibited itself in an air brake valve which he designed and succeeded in getting the Grand Trunk Railway, of which his father was Superintendent, to adopt. Although still in short trousers, he lectured before the engineers of this railroad on his valve and the air brake in general.

About this time he went to Buffalo and entered the employ of the Constructor's Plant



William T. Price

Manufacturing Company, where he soon became Chief Engineer. This concern was, however, too small for his abilities and he went to the Lackawanna Steel Company.

Mr. PRICE now realized that if he was to advance any higher he must have more education. In the fall of 1903, he presented himself at Cornell University and passed all the entrance examinations except languages. He finally overcame the objections of the faculty and was admitted as a special student.

The end of the first year saw his funds exhausted but not his desire to obtain a college education. Again he placed his case before the faculty and persuaded them to employ him as an instructor in mechanical drawing to pay for his tuition and board. His third year he served also as assistant professor of thermodynamics. In 1906, he was graduated, having completed the prescribed four years' course in three years. Other accomplishments of his college career were the invention of a toboggan, the invention of a brick press, winning the welterweight championship of Cornell and election to the presidency of the sparring club.

After leaving college, he, together with eight friends worked their way to Europe on a cattleship and arriving there, toured fived countries on bicycles. While on this trip he contributed to several newspapers in the United States. These articles, copies of which have been preserved, show an excellent style, close powers of observation and a keen sense of humor.

Returning from Europe he was employed by the Wheeling Mould & Foundry Company, where he remained until 1907. He was married on Thanksgiving Day, 1906. In 1908 he entered the sales department of the De La Vergne Machine Company and in 1909 was placed in charge of the Philadelph[illegible] branch office. During the ne[illegible] acted in a general advisor[illegible] neering matters and finally [illegible] was given complete ch[illegible]rge of the [illegible]gine designing and sales department.

He left the De La Vergne Machine Company in 1917 and founded the Price Engine Corporation. The first license to use his system

of handling fuel was granted the Rathbun-Jones Engineering Company.

In February, 1919, he entered into a license agreement with the Ingersoll-Rand Company for building and marketing engines working on his principles, and also entered their employ as chief engineer of the oil engine department.

He was a member of the American Society of Mechanical Engineers and the Engineers' Club, New York City.

The secret of Mr. PRICE's success is best explained by the following remark he once made: "The hard thing is the worth while thing. No man ever got anywhere by doing the easy things of life. Tackle the biggest job you can find and don't give up till you put it over. Then look around for another."

Mr. PRICE left a wife and five children and a big hole in the hearts of a multitude of friends.

BURN COAL—SAVE OIL

"THERE IS one thing I want to clear off my conscience," says FLOYD W. PARSONS in the *Saturday Evening Post*. "Many agents of fuel oil concerns have been advancing beautiful arguments of late urging the substitution of oil for coal in the production of steam for industrial purposes. Coal does make a sort of mess round a power plant, and is far from being as clean and handy as oil when used as a fuel. However, I want to go on record as saying that the substitution of oil for coal for steam-raising, in view of the present world outlook with regard to oil resources, is to my mind a practice that should be stopped. We have a coal supply that will last 500 to 2000 years, and an oil supply that may be exhausted in ten or twelve years. Oil has essential uses, where nothing else can be substituted for it. Furthermore, at present prices it is far more expensive than coal, even when the latter is sold at record figures. Oil at only $1.40 a barrel is equivalent to bituminous coal at $6.73 a ton; oil at $1.60 a barrel is equivalent to bituminous coal at $7.70 a ton. Very few plants are paying that much for coal or so little for oil."

Let those who contemplate the use of oil for power purposes consider these words of M. L. REQUA, one of the nation's leading authorities on oil: "For petroleum there is no satisfactory substitute as a lubricant; its exhaustion spells commercial chaos or commercial subjugation by the nation or nations that control the future source of supply from which petroleum will be derived. There is but one escape, and that is the discovery of some substitute, now unknown, that will as effectively and economically lubricate the machinery of the nation."

INDUSTRIAL DEVELOPMENT IN SOUTH AMERICA

SOUTH AMERICA, a continent long famed for its industrial possibilities, and which has yielded untold millions in wealth to those who had the hardihood to venture forth and aid in the development of that part of the world is the subject of a letter sent us by the Guaranty Trust Co. of New York.

Under the title *Electric Furnaces, Power Plants and Metallurgical Development in South America,* is discussed numerous recent industrial developments. It is pointed out that vast resources are available for the development of hydro-electric power which will make possible and profitable a great many commercial enterprises.

The falls of the Iguazu afford the best single resource in Argentina and one of the best in the world. Accordingly, the Argentina Government, has inaugurated a survey preliminary to the construction of a power plant there. It is reported that an international power plant, with a capacity of 150,000 horse power, will be erected jointly by the Governments of Argentina, Uruguay, and Brazil.

For instance, in Argentina, we are told the Iguazu of the northeastern corner of the country and the great group of water power resources in northwestern Patagonia, Neuquen, Rio Negro, and Chubut are capable of producing enormous quantities of hydro-electric power. Owing to their remote locations, they have attracted less attention than the limited resources of Cordoba, Tucuman, and Mendoza.

DR. JULIUS KLEIN, the United States Commercial Attaché to the Argentine Republic, says that power plants could well be established near Salta in the northwest, near Iguazu, and in the Rio Negro district, to serve Bahia Blanca of the southeast, and that there will be a great demand for electric power for supplying the various railroads which contemplate the electrification of their lines. At the present time the Argentine railways use three-fourths of the coal consumed in Argentina.

Brazil has extensive plans for the development of interior transportation, including the construction of power plants for industries and the electrification of railways. The Director of Public Lands and Colonization, called last August for bids for the erection of a power plant of 30,000 horsepower on the river Jacuhy.

The Itabira Iron Ore Company, Limited, recently secured a concession from the Brazilian Government to construct and exploit high temperature furnaces, a steel factory, and reducing apparatus, and plans to electrify the Victoria-Minas railway, for which an electric power plant will doubtless be constructed. An electric smelting plant, the first of its kind in South America, will be built in Ribeiro Preto, Province of Sao Paulo, by the Companhia Electrica Metallurgica Brazileira. The construction of the mill will be started as soon as the American contractors can get their engineers on the ground. The mill will be 75 miles from the mines of iron ore in the State of Minas Geraes.

Bolivia in its present stage of development is a country of mines, though other resources exist. The greatest hydro-electric resources are those in the vicinity of La Paz, Tres Cruces, and Colquechaca and plans for their exploitation have been made. The three initial power plants will entail an expenditure of $10,000,000 and will require large quantities of other machinery and electrical accessories in addition.

Hydro-electric power is beginning to be utilized by the tin and copper mines of Bolivia. The Guggenheims of New York have acquired rights to three tin mines in the Department of La Paz, consisting of more than 4,000 hectares. Water and power rights to some six streams in the vicinity of the mines have been secured and a hydro-electric power plant is to be built. The installation of a smelting plant run by electricity is under consideration. The company plans to found a town below the mines and construct an electric tramway to it.

The mines of Peru are beginning to appropriate the hydro-electric resources of the Peruvian Andes. The Cerro de Pasco Copper Corporation of Cerro de Pasco, Province of Junin, Peru, is now installing a large up-to-date smelter at Oroya and providing modern housing and other facilities for its workingmen.

A vanadium ore-reducing plant for the mines of Minasgra, Peru, is to be built at Jumasha, Peru, by the Vanadium Corporation of America, of Pittsburgh, Pa. A hydro-electric plant capable of furnishing 20,000 kilowatts power for treating the ore is to be constructed about 25 miles from Jumasha.

Chile has vast hydro-electric resources, which have been but slightly developed. German and British capital, chiefly, has been invested to provide public utilities in Chile.

The most definite development project in Chile at the present time is that provided by a $35,000,000 loan by the Chilean Government, $10,000,000 of which has been appropriated for the electrification of the railway from Santiago to Valparaiso, via Casablanca. The electric generating station is to be located on the Aconcagua River about 30 miles from Llai-Llai.

Moreover, an internationally organized company (Anglo-Chileno-Americano) in Valparaiso plans to construct a 100,000 horsepower plant for supplying electric lighting and power to that region.

The Antofogasta-La Paz Railway, a British owned line and one of the largest in the nitrate region of northern Chile, is to electrify its lines at a cost of $7,500,000, which project will entail the erection of a power plant.

Colombia with her abundant hydro-electric resources, about five electric light and power plants representing about one million dollars, and various electric and steam tramways, operated in the five chief cities, exhibits an attractive field for electric installations. Her cities are becoming modernized with the development of her industries and her mineral resources are being exploited as never before.

These developments are welcome. Anyone who has travelled through South America will appreciate what they will mean to the resident populace and can foresee the improved standards of living which they will inaugurate. The outside world will benefit by such industrial development in a land so rich in natural resources.

These enterprises are worthy of consideration. They do not involve speculation but represent sound and conservative investment of capital and in the normal sequence of events, a profitable return may be expected.

South America apparently offers a fertile field for industrial development which unquestionably will be accomplished in the very near future.

The electric furnace in actual use has reached a temperature of 3,500 degrees C., says the *Sibley Journal of Engineering*. Recent experiments have, however, developed a furnace which gives a temperature of 4,500 degrees C., enough to volatilize diamonds. A comparison of these temperatures with that of the sun, which is estimated at 5,000 degrees C., gives a striking idea of what can be accomplished in handling refractory substances with electric heat.

In the course of a recent lecture to the Chemical Society, Professor J. C. McLennon said that it would be possible to produce 10,500,000 cu. ft. of helium gas per annum at Calgary, Canada, with a plant that would cost less than $500,000. The cost of the gas would be less than 2½ d. (or say five cents) per cu. ft. As artificial illuminating gas cost less than one-tenth of this we cannot yet afford to use helium for our balloons.

According to *Commerce Reports* India's 1920 wheat crop is estimated at 375,884,000 bushels.

The treasury department says that a million dollar bills weigh 3,000 pounds.

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Book Reviews

THE COST OF MINING, by JAMES R. FINLEY. Cloth; 6¼x9¼; third edition; charts and tables. New York: McGraw-Hill Book Co., Inc.

IN THE THIRD edition of his book which has already attained a prominence beyond that included in the scope of the mining industry, Mr. Finley has considered his subject in a much broader manner than that indicated by the title. The matter contained in the two earlier editions has been entirely revised, enlarged, and reset, so that the presentation represents conclusions which not only consider the result of experiences in the mining business under diverse conditions but also include generalizations on geologic history and processes which explain the origin and govern the distribution of important minerals.

The first five chapters are devoted to broad discussions of the economic angles of the industry, the general principles of costs, profits and nature of mining investments, the essential qualities and use of capital, factors governing cost variations and the methods of cost analysis. The remaining chapters deal with the individual production of minerals and their costs.

The reader cannot fail to be impressed by the thoroughness which Mr. Finley has exercised in his preparation of the book. His comprehension of the various factors that enter into costs of mining, his clear explanation of each point, and the logic embodied in his various arguments make the volume valuable not only to the engineer but to the financier and the economist as well.

HOUSE WIRING, by THOMAS W. POPPE. 160 original engravings, fourth edition. Price $1.00, New York: The Norman W. Henley Publishing Company.

THIS TREATISE describes and illustrates up-to-date methods of installing electric light and power wiring, bell wiring and burglar alarm wiring. It is intended especially for the electrician, helper and apprentice. It aids in solving all wiring problems and contains nothing that conflicts with the rulings of the National Board of Fire Underwriters. It contains just the information needed for the successful wiring of a building.

PUMPING BY COMPRESSED AIR, by EDMUND M. IVENS, B. E., M. E. member of the American Society of Mechanical Engineers. Second edition revised, containing an additional 30 pages of text and eighteen illustrations together with several formulas and tables; 266 pp.; New York, John Wiley & Sons, Inc. London, Chapman and Hall, Limited.

IN THE PREPARATION of this book the author states it was done with the purpose of placing in the hands of the student a comprehensive theoretical study of the subject and at the same time to instruct the operating engineer in the practical essentials of actual installations. In order to realize the first object, the views of Professor Elmo G. Harris, George Jacob Davis and Carl R. Weidner and for the second object, an article by Arthur H. Diamant have been incorporated.

In the last few chapters of the book, a brief description of the fundamental principles of hydraulics and thermodynamics is given because of the author's belief that a knowledge of both of these subjects is necessary to a thorough understanding of compressed air pumping.

The volume should convey to the student all the information necessary to intelligently design, install and operate a compressed air pumping plant of any size or capacity.

The added matter in the revised edition consists principally of very reliable and carefully compiled operative data which should prove of interest and value to the student as well as to the designing and operating engineer.

New Mining Publications

THE BUREAU OF MINES of the Department of the Interior has published the following new bulletins and technical papers:

BULLETIN 180. Bibliography of petroleum and allied substances, 1917, by E. H. Burroughs. 1920. 170 pp.

TECHNICAL PAPER 259. Production of explosives in the United States during the calendar year 1919, with notes on coal-mine accidents due to explosives and list of permissible explosives tested prior to May 31, 1920, by W. W. Adams. 1920. 32 pp.

TECHNICAL PAPER 266. Coke-oven accidents in the United States during the calendar year 1919, by W. W. Adams. 1920. 25 pp.

UNITED STATES BITUMINOUS COAL COMMISSION. Stabilization of the bituminous coal industry. Extracts from the award and recommendations of the United States Bituminous Coal Commission. 1920. 16 pp. Distributed by the Bureau of Mines in coöperation with the Council of National Defense.

NOTE—Only a limited supply of these publications is available for free distribution, and applicants are asked to cooperate in insuring an equitable distribution by selecting publications that are of especial interest. Requests for all papers can not be granted. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

THE AUSTRIAN ENGINEERING AND INDUSTRIAL OUTLOOK

By HERMANN BRINKMANN

THE MANAGING DIRECTOR of one of the largest of the Austrian engineering establishments advises your correspondent as follows:

The treaty of St. Germain has left German Austria as merely one of the miserable remains of the historic institution of Austrian monarchy. This embryo state counting six millions of inhabitants, of which two millions alone are in the former metropolis of Vienna, is called upon to work off the *karma* with which it was charged by a former most ill-conceived imperial policy. Only fancy, a country short of coal, being unable to grow the food most necessary for the upkeep of the human body and in addition having to cater for a city of two millions like Vienna, is supposed to reëstablish economic order in the greatest political anarchy that Europe has known for centuries past.

Quite apart from the crushing effect of the enormous war debt left to the dwarfed state, how can something be created out of the "nothing," when the state debts continually increase

by 22 *milliards* of kronen per month through the paper money inflation, thereby causing the downward tendency of the Kronen exchange? All reasonable beings are long since convinced that none of the countries broken away from Austria-Hungary can subsist in isolation, with their absurd, indented, indefensible frontiers, and with their former economic relations broken and destroyed. In order that men may draw wealth from the earth, and in order that they may interchange this wealth peacefully and regularly, it is first essential that the land be well divided, that the frontiers be safe, and that the balance between nations be more or less guaranteed. But what have we in German Austria to-day?

We have about 2,400,000 farming population, who under the most favorable conditions can supply the remaining 3,600,000 souls during a period of perhaps 100 days of the year. The rest of our sustenance we must procure from abroad. But we are short of coal, raw materials and sugar. To import these, we are obliged to export goods. The only returns we can offer are wood, magnesite and some ore. Besides these raw materials there are certain Austrian manufactured goods which might be considered as national assets and which are called upon to balance the two sides of the budget. The overthrown Austrian monarchy was principally an agricultural state cultivating cereals, potatoes and beetroots, whilst the mining industry yielded per annum: lignite about 140 million hundredweight and pit coal about 96 million hundredweight.

The Austrian republic as constituted at present consists of the Alpine countries, Lower and Upper Austria, Salzburg, part of Steiermark, Kaernten, Vorarlberg and North-Tyrol. The pits in the Alps yield hardly more than 500 cars of coal a day of most inferior quality; indeed this fuel is so bad that before the war these pits were not worked at all not being worth operating expenses. In order to enable Austrian industry to get upon its feet there will be required at least three times the available quantity of coal (but of course of a much better quality) which it obtains from local resources. By a treaty just concluded with Czecho-Slovakia, Austria will receive from the latter about 35 per cent. of her coal requirements. However, she is still 65 per cent. short of coal, the sequence of this being that a great many factories are obliged to procure coal from wherever they may, paying such exorbitant prices that they border on economic madness. For instance for low grade lignite, 4,000 kronen per ton is paid; for pit coal, 5,000 to 6,000 kronen; for coke even as much as 7,000 to 8,000 kronen per ton.

Furthermore, the greatest part of our raw materials must be bought abroad. But owing to the ridiculously low value of the Austrian kronen the prices for these raw materials are about forty times higher than those before the war. In addition to this must be figured the increased tariffs of railway freights, which are 60 times higher than before the war; with day wages of workmen and salaries of skilled employees ten to fifteen times higher than before the war. Compared with the year 1913 the taxes are six times greater. Taking all these points together, it is clear that Austrian industry drives rapidly towards a catastrophe.

Of course, it is out of the question that considering the burdens that choke Austrian industry it can be a competitor in world markets; the result is that Austria cannot export and in spite of the scarcity of goods people in the country cannot afford to purchase these accumulating stocks.

How can we get out of this chaos? In the first instance the Government must reduce its enormous expenses; the eight-hour day must be abolished; the paper monetary inflation must be stopped; this awful class strife, leaving nothing but strikes in its wake, must cease. Austrian industry requires earnest consideration on the part of the Government in order to pull up again and restore the confidence of the world, now quite lost.

Pneumatic Patents

In the United States

OCTOBER 12

1,355,175. PERCUSSIVE TOOL. William A. Smith, Easton, Pa.

1,355,270. PNEUMATIC GRADER AND METAL-CATCHER. Alonzo J. Roberts, St. Louis, Mo.

1,355,444. METHOD AND MEANS FOR FEEDING POWDERED FUEL. William M. Baxter, Chicago, Ill.

13. The method of feeding powdered fuel which consists in preliminarily mixing a quantity of air with powdered fuel, converting the resultant stream of fuel and air into a hollow cylindrical stream of increased cross sectional area, and causing a plurality of jets of air under pressure to penetrate said hollow stream from the inside thereof and expand within said stream.

1,355,504. AIR-CLEANER. John Riise, Doylestown, Ohio.

1,355,508. VACUUM ASH-SIFTER. August E. Roever, Brooklyn, N. Y.

1,355,529. VACUUM-TYPE CONVERTER. Wilfred T. Birdsall, Montclair, N. J.

1,355,596. AIR SEPARATOR. George S. Emerick, Easton, Pa.

1,355,617. SEPARATOR FOR VACUUM SYSTEMS. Henry C. Niemeyer, Philadelphia, Pa.

1,355,679. VACUUM APPARATUS. Thomas McConnell, New Kensington, Pa.

1,355,688. FLUID-PRESSURE MOTOR. Rufus F. Pack, Cedar Vale, Kans.

1,355,787. COTTON-HARVESTER. John T. Skillins, Westbrook, Me.

OCTOBER 19.

1,355,962. FLUID-PRESSURE MOTOR. George H. Groth, Dayton, Ohio.

9. The herein described method of utilizing air or similar fluid under pressure which consists in expanding the fluid from a high pressure container through a utilizing mechanism into a low pressure container and then expanding the increased volume of fluid at lower pressure simultaneously from both containers through another utilizing mechanism to normal or neutral pressure.

1,355,998. GAS MIXER. Joseph Needham, New York, N. Y.

1,356,160. AIR-PUMP. Ira Lawley, Groesbeck, Tex.

1,356,196. METHOD OF CONDENSING A VAPOR IN A NATURAL GAS. James T. Duffy, San Antonio, Tex.

1,356,205. CONTROL-VALVE FOR COMPRESSORS. Fred J. Heideman, Detroit, Mich.

1,356,496. VACUUM-PUMP FOR PLAYER-PIANOS. William E. Shore, New York, N. Y.

Recent British Patents

149,705. MOTOR. J. Mungall and A. Ritchie, of Carlisle.

149,161. HOSE COUPLING. L. Lawson, of Newcastle-on-Tyne.

149,423. LUBRICATING DEVICE FOR COMPRESSOR. The Westinghouse Brake Co., Ltd., of London.

147,991. PIPE COUPLING. N. B. Ghadially, of Bombay.

148,669. BRAKE. The Westinghouse Brake Company, Limited, and A. W. Rendell, of London.

150,177. GLAND FOR COMPRESSOR. O. Deam, of Calcutta.

149,544. AIR COMPRESSOR. R. Brusa, of Milan.

149,890. COMPRESSOR. P. Pritchard, of Birmingham.

Austrian Patents Jan.-July, 1920

Compiled by Hermann Brinkmann, Vienna, for COMPRESSED AIR MAGAZINE.

January. 5b. Friedr. Griebsch, Vienna. A-3580-17, applied for 8.1.1917. Device for making drilling holes for pit blasting.

March. 5b. Heinr. Bade, Wunstorf i/Manover. A-1982-15, applied for 5.10.1915. Working stage for shaft galleries.

April. 27d. Maschinenf. Augsburg-Nurnberg, Augsburg. A-902-15; applied for 3.1.15. Inlet valve for compressors.

May. 87. Gebr. Bholer & Co., Vienna. A-569-19. Applied for 2.19.19. Piston shaped reversing slide for tools or machine working with percussion pistons.

June. 5a. Anschutz & Co., Neumuhlen near Kiel. A-808-16; appl.f. 2.24.1916. Rock drill to drill vertical holes. 5a. Wilh. Zimmermann, Erkelenz. A-1143-18; appl.f. 2.27.1919. Releasing and hauling device for deep drilling. 5b. Jakob Fecht, Altenwald. A-166-18. Appl. f. 1.12.1918. Iron complete tubbing. 5b. Walter Kimber, London. A-540-16. Appl.f. 2.7. 1916. Rock drill with hammer like working piston 49c. Hirmann Stephan, Budapest. A-4354-17. Appl.f. 9.17.1917. Process for making tools such as milling cutters, steels, etc. 80a. Eugen Fochtenberger, Mannheim. A-37-83-17. Appl.f. 8.13.1917. Hammers, particularly granulating hammers, for stone working. 87b. Gebr. Bohler & Co., Vienna. A-1404-19. Appl.f. 4.23.1919. Compressed air striking tool operated by two valves.

July. 5b. Aug. Berner, Nurnberg. A-6618-14. Appl.f. 7.30.1914. Cutting and rock drill machine with two single-acting compressors.

Latest Patents in Germany

Abstracted by H. Brinkmann, Vienna.

749,716. Forstersche Maschinen & Armaturen-Fabrik, of Essen-Altenessen. Pawl on rotation device for coal pick-hammers. 1.6.1920. F.40133.

749,723. Heinrich Freise, Bochum, Dorstenerstr. 228. Steels for hammer drills, etc. 30.6.1920. F. 40252.

749,750. Rudolph Warmbt, Waldenburg, Silesia. Pneumatic hammer drill or rock drill with detachable or undetachable air chamber for receiving or leading-off of the exhaust air. 28.7.1920. W.56082.

749,656. Heinrich Rohde, Unser Fritz, Westfalia. Blowing-off device for the rock dust from bore holes. 10.7.1920. R.50498.

749,705. Siemens-Schuckertwerke, Ltd., Siemensstadt, Berlin. Handle device for rock drills. 8.1.1920. S.43657.

749,707. Siemens-Schuckertwerke, Ltd., Siemensstadt, Berlin. Rock drill with turning device. 10.1.1920. S.43676.

5b, 13. N.18557. Heinrich Nickolay, Bochum. Coal pick hammer with device for allaying of dust. 7.2.20.

47g, 12. Sch.56628. Dr. Eng. Kurt Schone, Hamburg. Valve for pumps and compressors with nozzle shaped extension of india rubber or similar material. 31.10.19.

24b, 751383. Engineering Works Balcke, Neubeckum. 29.7.19.

59a(9), 325848 of the 11th January, 1920. Hundt & Weber, Ltd., Geisweid. Device for automatic starting and stopping of pumps.

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Notes of Industry

In the United States

In a special report on the textile markets of Brazil published recently by the Bureau of Foreign and Domestic Commerce, it was stated that during the year 1918 Brazil imported $33,000,000 worth of textiles, $5,750,000 of which was furnished by the United States.

The Car Service Division of the American Railway association states that a new record for this year was set during the week ending October 9. The number of cars loaded with commercial freight on railroads of the United States was 1,097,787 as compared with 982,171 for the corresponding week of 1910, and 969,722 during the corresponding week of 1918. This was the first week in which freight car loading passed the million mark.

The First Aid Team of the Butte & Superior Mining Company won the 1920 championship in the First Aid contest held in Butte recently. There were five teams tied for first place, which necessitated a play-off. In the play-off the Butte & Superior team came through with a perfect score of 100 per cent.

The Bethlehem Shipbuilding Corporation has secured contracts for four 20,000 ton, combination iron, oil and ore carrying ships to be driven by Diesel engines and to cost $5,000,000 each. They expect to build these ships at their Sparrows Point Yard, Md.

Bankers, producers, importers and exporters from all parts of the United States have undertaken the organization of a $100,000,000 foreign trade financing corporation, practical work on which has already been begun.

Construction of three long tunnels has been approved by the State Railroad Commission of Colorado. One will have a length of six and one-half miles, and is to be made through James Peak, on the Denver & Salt Lake line, at an elevation of 9,100 ft. The second will be six miles long, and will be located near Marshall Pass, at an elevation of 9,500 ft. The third will be considerable shorter, and will be located near Cumbres Pass. All three are involved by the construction of new and connecting lines, and form part of a scheme for obtaining easier grades through the mountains of Colorado.

The Compressed Air Society of Quincy, Ill., unanimously voted that the society go on record as being opposed to the Metric System.

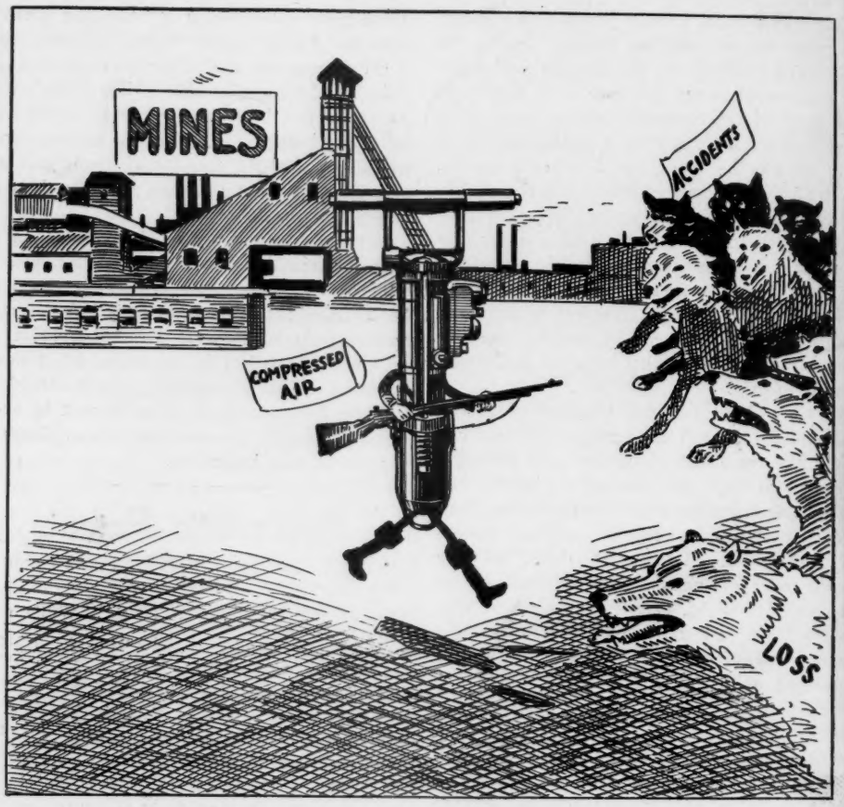
The United Kingdom

The Clyde Shipbuilding output for last October showed a considerable reduction, this being largely due to the national coal strike. Within a few days of the commencement of this strike many of the steel-works had to close down, with the result that the raw material supply to the shipyards was almost immediately cut off, as the conditions during the past two years have been such as to entirely preclude the building up of large stocks of material by either the producer or the consumer.

The actual figures relating to the Clyde shipbuilding district for October showed that thirteen vessels were launched, aggregating about 28,000 tons, which was over 20,000 tons less than the output for September. This is the more to be regretted as this district was well on the way to break its own previous record, which was established in 1913. The total tonnage launched for the ten months of 1920 up to November amounts to 517,000 tons, compared with 559,800 tons for the same ten months in 1913.

A two-hundred ton self-propelled floating crane has been installed by the Mersey Docks and Harbour Board in Liverpool. It has been built by the firm of A. F. Smulders of Schiedam, Holland. It is capable of lifting a weight of 200 tons to a height of 170 ft., above the water line, at a distance of 110 ft. from the centre line of the crane, or a load of 150 tons to the same height at a distance of 143 feet.

The crane can make a full circle with the full load of 200 tons, and can be derricked through an angle approaching 40 degrees. The tower is 66 ft. high and the end of the jib at its highest position is 240 ft. above water level. The jib has two sets of blocks and hooks, lifting independently or together, and on trial a hoisting speed under full load of five feet per minute has been attained. The crane propelled itself in the Mersey during the trials at a speed of over four miles per hour.



KEEPING THE WOLF FROM THE DOOR

From Austria and Succession States

The extended "kaolin" (china clay) layers near Allerheiligen in Austria, have been bought up by the Schwertberger Kaolin-works from the former proprietors, the Montan Company, Prague. Under the management of experts the existing washing plants are now being improved in accordance with the most modern requirements, and it is intended to increase the yearly output up to 800 wagons. According to expert opinion the existing kaolin layers are almost inexhaustible. The fully paid-in capital amounts to 6,000,000 kronen. The paper and ceramic industries in Austria will thereby become independent from foreign countries.

The so-called "air bottles" which since the war had disappeared have again been brought on the market by the Axtor Company. These bottles are used for pumping pneumatic tires. They are very handy and can be easily put into the tool box fitted at the foot bridge of the taxi. The filling consists of pure nitrogen, being compressed up to about 150 atm. and is sufficient to pump up about six large tires. By means of an exactly worked valve and a reliable gage, the pressure in the hose can be regulated to a nicety. By applying nitrogen instead of air the rubber hose is less subject to wear, and considering the low cost of the air bottle and the low expenses for filling this accessory, it will no doubt come quickly into favor with automobilists.